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CHINA: Energy

Coal Industry: Developments and Outlook

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CONTENTS

S&T Development for 1990-1995 Detailed

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[Article: "Outline Plan for Scientific and Technological Development in the China Unified Distribution Coal Mine Corporation, 1990-1995"]

[Text] **Introduction**

Coal is China's primary energy resource. Coal accounted for 73.1 percent of our total primary energy resource production in 1988 and for 76.1 percent of our primary energy resource consumption. Projected coal output by the end of this century is 1.4 billion tons and it will still account for over 70 percent of energy resource production and consumption. There has been substantial growth in coal production and construction over the past 10 years. Yearly output increased from 620 million tons in 1980 to 979.87 million tons in 1988 (331.52 million tons of it from the China Unified Distribution Coal Mine Corporation). Development of production and construction has also brought obvious changes in the characteristics of basic technologies in coal mines. We have now completed four modernized mining bureaus and 32 modernized mines. The extent of mechanization in coal extraction in unified distribution coal mines reached 58.02 percent in 1988, including 31.36 percent for fully mechanized mining. We have established 17 specialized research organs with a relatively full complement of academic disciplines and we have established several experiment and testing measures with advanced levels. We have 14 provincial-level research organs. Coal institutions of higher education, information, design, and manufacturing units are another scientific research and development force. The coal system now has a rather good capacity for self-development and attacking problems. The over 70 research institutes in bureaus, mines, and key coal machinery plants are a basic force for developing and absorbing new technologies in enterprises. By the end of 1988, they had made 2,300 S&T achievements and activities to extend and apply technical innovations and new technical achievements by large numbers of coal S&T personnel have effectively promoted development of the coal industry.

1. In the area of geological exploration, we have gained a basic grasp of the distributional laws of China's coal resources and made preliminary changes in the backward situation in some exploration measures. Comprehensive application of new exploration technologies and new measures in recent years led to the discovery of extra-large coal fields at Huainan Yingfeng, Shandong Juye, Shaanbei [north Shaanxi] Shenmu, and other places which have provided several reserve base areas for developing the coal industry.

2. In the area of mine design, design technology reforms centered on mine extraction technologies since the 1980's produced advanced indices of a design roadway tunneling rate of 100 meters/10,000 tons, productivity of 5 tons/manshift, and shaft construction schedules of 5 years at Jincheng Chengzhuang Mine, which has a yearly capacity of 4 million tons, and at Jining No 3 Mine, which has a yearly capacity of 5 million tons.

3. In the area of shaft construction, achievements with special shaft sinking methods have created the conditions for developing the east China region. Vertical shaft matching mechanized work lines centered on 0.6 cubic meter rock loaders can meet the requirements of sinking vertical shafts to depths of 700 meters. We have formed preliminary mechanized tunneling work lines for rock tunnels, inclined shafts, and coal and semi-coal rock tunnels. The average shaft construction schedule during the first 3 years of the Seventh 5-Year Plan had already been reduced to 71.7 months.

4. In the area of extraction technologies, we have focused on strike longwalls and we have recently developed inclined longwall coal mining techniques for coal seams with suitable conditions. We have achieved rather good economic results in experimental extension of reforms in roadway opening deployments and pillarless coal extraction technologies. We have put together a set of complete extraction technologies and regulations for mining "three beneaths" [beneath roads, railways, and bodies of water] coal which have enabled recovery of reserves in mines in "three beneaths" areas. We have made excellent achievements in using hydraulic coal mining under suitable conditions and gratifying advances in controlling landslides, adoption of new techniques, and other areas in strip mining.

5. In the area of mechanizing coal extraction, our coal mining equipment now basically comes from domestic sources and we have formed a relatively complete technical research, design, manufacturing, testing, inspection, and repair system and multilayer technology structure for coal mining equipment. During the 10-year period covered by the Fifth and Sixth 5-Year Plans, output from mechanized mining accounted for 80 percent of increased stope output in unified distribution coal mines and development of mechanized coal mining has now become a primary way to increase coal output.

6. In the area of reforming mine support materials, extending and applying various replacement materials for pit timber and new support technologies have reduced pit timber consumption in unified distribution coal mines from 90.3 cubic meters/10,000 tons in 1980 to about 50 cubic meters/10,000 tons at present and created the conditions for mechanizing and centralizing mine production.

7. In the area of mine safety technologies, we have gradually attained a grasp of the causes, conditions, and development processes behind many types of hazards and established preliminary comprehensive prevention measures and technical equipment suited to concrete conditions in Chinese coal mines which have increased our capacity for preventing and fighting mine fires. This

was the technical foundation for the 70 percent reduction in the accidental death rate in unified distribution coal mines since 1978.

8. In the area of mine electrification and communications, voltage increases and renovation of low-voltage electrical mine equipment and attacks on key problems with electric motors in coal shearers and conveyors have created the conditions for developing mechanization. We have attained preliminary solutions to mine dispatching and communications technologies and we have developed microwave ground communications in mining regions and dedicated communications lines for the coal system.

9. In the area of mine hoisting and haulage, we have attained rather good economic results from improving electric control systems for mine hoists, matching use of lightweight containers and spring valves, and so on. Technical improvements in mine hoisting and haulage systems have provided the conditions for exploiting potential in old mines.

10. In the area of coal processing and utilization, we can do our own designing and outfitting for coal dressing plants with a 3 million tons/year capacity. The proportion of raw coal from unified distribution coal mines that was marketed directly without washing, dressing, and screening dropped to 7.33 percent in 1988. Appropriate technologies in the areas of comprehensive utilization of low heat value fuels and processing and purification of coal slurry have played important roles in increasing economic benefits for coal mine enterprises and improving the environment. New Chinese coal classification standards have provided the technical basis for macro guidance of the rational development and utilization of coal.

11. In the area of applying new technologies, the use of computers since the 1980's in safety monitoring and monitoring and control, scientific research and design, manufacturing, geological exploration, statistical computations, finance, costs, dispatching, industry surveys, and other areas have provided technical economics benefits to varying degrees and brought preliminary improvements to the technical situation in coal mine production and management and administration.

The technical face of the coal industry is still very backward. It lags substantially behind the world's main coal producing nations, and it has the slowest rate of growth among all industries in China. The Economics Institute in the State Planning Commission has estimated that the rate of technical progress in the coal industry from 1953 to 1984 was the slowest among the 17 sectors that were independent accounting industrial enterprises under ownership by the whole people. It was just 0.79 percent (the figure for all of China's industrial enterprises was 1.82 percent). Technical progress accounted for a very low proportion of growth in gross value of output, just 9.2 percent (the figure for all of China's industrial enterprises was 20 percent). The backwardness of technical development in the coal industry is manifested in:

1. Low technical and equipment levels and large amounts of heavy physical labor. The degree of mechanization in coal extraction in unified distribution coal mines in 1988 was only 58.02 percent, including just 31.36 percent for fully mechanized mining. The extent of mechanization in tunneling and loading was just 55.53 percent and only 5.67 percent for mechanized tunneling. The level was best for coal extraction equipment but most of it was at levels of the early and middle 1970's.

2. Rather serious safety accidents and a high death rate. The death rate per 1 million tons in unified distribution coal mines in 1988 was far higher than in foreign countries. Moreover, the number of deaths from pneumoconiosis was 2.25 times the number of accidental deaths in 1987.

3. Low labor productivity. The results of technical progress were negated by worsening extraction conditions, poor scientific management, low quality, and other social and economic factors. Labor productivity in unified distribution coal mines was just 1.092 tons/manshift in 1988.

4. A low degree of coal processing and utilization and relatively severe pollution from coal. The proportion of raw coal washed was just 26 percent.

The main reasons for the backward situation in coal mine technology are:

1. Too-low coal prices and substantial increases in raw materials prices caused enormous industry-wide losses in the coal industry. Coal mining machinery enterprises lack the financial resources to carry out technical transformation and develop new products and new technologies. Added to the absence of policies and mechanisms to encourage the coal industry to adopt new technologies, coal mine enterprises lack the strength and motivation for technical progress and are slow to renovate and transform equipment.

2. There have been substantial reductions in S&T inputs in recent years. Scientific research expenditures allocated by the state in all categories during the first 3 years of the Seventh 5-Year Plan were down 30 percent compared to the last 3 years of the Sixth 5-Year Plan and subsidies to the coal industry for scientific research expenditures were down by 70 percent. Reduced industry expenditures and rising materials prices meant that industry expenditures allocated by the state were less than 30 percent of actual industry expenditures. Existing S&T forces and facilities cannot be fully utilized and some S&T achievements cannot be extended and utilized well.

3. S&T staffs are unstable and there are problems with personnel continuity. In the current situation of reforms in the S&T system, no concrete matching policy system

adapted to the laws of coal S&T work has taken shape, which has led to increasing instability in S&T staffs which formerly were unable to adapt to coal industry development both in terms of quantity and quality. The phenomena of "no one coming in and no one staying" are becoming increasingly serious.

4. There has been a serious decline in the quality of workers. Over half of the workers in some mining bureaus are peasants who work on a rotating basis. Even some technical workers rotate jobs. The result is that coal mine workers, who formerly were of low quality, are even less capable of meeting the needs of technical progress.

5. Leading cadres still do not truly understand reliance on technical progress. In the present situation of comprehensive contractual responsibility and most enterprises suffering losses, a substantial portion of enterprises still lack the pressure and capability of relying on technical progress to develop production.

I. Development Goals

A. The Guiding Ideology of S&T Development

S&T work in the coal industry should be oriented toward coal production and construction, should focus on the three main bodies of coal industry production, construction, and economic diversification and the three main aspects of safety, efficiency, and modernized mine construction, and should concentrate forces to study and resolve key technical issues with major economic and social benefits in mechanizing extraction, tunneling, and haulage, coal mine safety, and coal processing and utilization. We should develop multilevel technologies, be concerned with applied research and technical equipment, actively extend new technologies which can be used in large numbers and over broad areas, and strive to attain optimum economic results. We should achieve the projected indices for coal mine full-staff efficiency, death rates per 1 million tons of coal, and raw coal output for the year 1995, and serve the goals of sustained, stable, and healthy development of coal production and construction.

B. S&T Development Goals

1. Gradually provide effective solutions for key technical problems urgently required in production and construction. In the latter part of the Eighth 5-Year Plan, we should devise effective methods for increasing unit output, unit driving footage, and efficiency at excavation faces, and basically solve extraction techniques for mining coal from hard-to-mine seams and under difficult conditions; technologies for preventing major terrible accidents; reform technologies for extracting standard roadway supports; improve the reliability of excavation equipment and large-scale coal dressing equipment; develop fully mechanized mining faces with daily output of 10,000 tons and monthly output of 200,000 tons; increase the degree of automation in certain production system links, and gradually undertake health monitoring and breakdown diagnosis technologies for some important equipment.

2. Basically achieve domestic sources for primary technical equipment in coal mines. Surpass Polish levels in technical performance, product variety series, product quality, and reliability in excavation machinery and safety equipment, and try to attain world levels of the early 1980's to be able to meet the needs of large mines and coal dressing plants for full sets of equipment and rather advanced levels, and attain international advanced levels at the time for certain technologies and even be able to export them.

3. Make rather obvious improvements in the technical economics situation in coal mines. The Unified Distribution Coal Mine Corporation should attain a mechanization level in coal extraction of 66 percent, including 36 percent for fully mechanized mining. The degree of mechanization in tunneling and loading should reach 66 percent, including 15 percent in fully mechanized tunneling of coal and semi-coal rock tunnels. The proportion of coal brought in for dressing should reach 29 percent. We should complete 93 modernized mines of different categories.

4. Make a turn for the better in coal mine safety conditions. Basically control the occurrence of gas, coal dust, roof falls, fires, water hazards, and other major terrible accidents, strive to control the increase in pneumoconiosis, attain the standard rate of 80 percent for comprehensive dust, and create technical conditions for attaining the specified goals in death rates per 1 million tons.

5. Strengthen scientific research reserve strengths, correctly handle the relationships between the present and the long term and between technical development and applied and theoretical research. In addition to focusing on solving current coal mine production and construction S&T problems, we should also be concerned with applied and theoretical research, attacks on key questions for components, soft science research and technical equipment, and achieve sustained and stable development of coal S&T.

6. There should be further improvements in personnel quality and measures in scientific research organs to enable them to better solve all types of major and complex technical problems in coal production and construction to provide certain specializations with scientific research personnel and testing measures at world levels. Cadres at the coal mine and department level and above should basically achieve the college level. Most workers in important technical jobs in coal mines should attain the level of graduates in similar job categories from coal mine technical schools.

II. Key S&T Tasks

A. Key Projects for Attacking S&T Problems

1. Raise coal field and mine geological exploration technical levels, provide new measures and new technologies for exploring resources in deep areas from old mines in east China, study on new methods in mine output forecasting, do forecasting and evaluation of deep geological structures, coal quality, coal seams, and so on.

Provide reliable geological conditions for achieving mechanized extraction. Use expanded research on various types of existing mine geophysical exploration measures and methods of explanation in conjunction with the required horizontal and directional drilling technologies to locate small faults that are not less than one-half the thickness of coal seams or larger than 2 meters as well as subsided columns more than 10 meters in diameter to attain a success rate of more than 85 percent.

Provide effective technical routes and special mining techniques for safe extraction of coal resources subject to Ordovician karst water threats. On the basis of attacks on key problems during the Sixth and Seventh 5-Year Plans, we have employed many types of geophysical exploration and geochemical prospecting measures, reinforced methods and interpretations, studied water burst mechanisms, monitored forewarnings of water bursts, and provided leading forecasts of the possibility of water bursts 30 to 50 meters ahead of excavation.

To gradually shift the deployment of exploration to west China, we should study new methods and new technologies for remote sensing, exploratory drilling, and geophysical exploration adapted to the geological conditions of strata at shallow and moderate depths in west China and new equipment for studying hydrology and engineering geology to explore water resources in arid and deep water level regions.

2. Accelerate the pace of mine tunnel construction. We should perfect and improve existing common shaft drilling technologies, including reinforced research on sounding and control of the geology of rock strata surrounding shafts and improved research on organizing tunnel construction so that the average rate of shaft drilling at trial points is a monthly shaft completion rate of 50 to 60 meters. We should also develop research on shaft drilling technologies for 1,000 meter deep shafts, continue to focus on solving problems with the destruction of frozen shaft walls, and propose shaft wall structure construction techniques and basic design methods adapted to strata deformation.

Solve problems with complete sets of technologies for fully mechanized tunneling in coal and semi-coal rock (f = 8), improve coal tunnel support, haulage, and other technologies, increase the reliability of tunneling equipment components, reinforce model experiments (including lifespan experiments) to achieve useful lifespans in mines of more than 1 year, monthly driving footages in coal and semi-coal rock of 800 meters and 500 meters, respectively, and yearly driving footages of more than 5,000 meters and 4,000 meters, respectively.

Improve existing hydraulic rock drilling rigs and the properties of rock tunnel drilling-blasting method mechanized work lines focused on side-dumping rock loaders, and increase the reliability and extent of domestic production of imported components. The useful lifespans of primary components should exceed 1 year and the accident rate should not exceed 5 percent. Develop portable hydraulic drills and hydraulic rock drills.

3. Raise the levels of mechanized mining technologies and improve coal extraction techniques. Further improve the results of fully mechanized mining, increase utilization rates for fully mechanized mining equipment, solve problems with rational matching of systems and auxiliary facilities, and improve coal extraction techniques. Increase the reliability of equipment and systems, study health monitoring and breakdown diagnosis technologies, and increase the operating time of coal shearers by 20 percent over present levels. In addition, develop high power, high reliability, and high traction speed coal shearers, large haulage rate and high lifespan work face scraper conveyors, fast-moving (including electrohydraulic control) hydraulic supports, high speed and high lifespan trough-following belt conveyors and coal face trough-following control systems to develop fully mechanized mining faces with daily output of 10,000 tons, monthly output of 200,000 tons, and yearly output of 2 million tons.

Achieve a basic solution to problems of extraction techniques for hard-to-mine coal seams, actively do research and experiments on technologies for mining coal beneath villages, continue to complete and improve mechanized extraction technologies for thin coal seams, inclined and steeply inclined medium thickness coal seams, and steeply inclined thick coal seams, and make major efforts to undertake work to attack key problems with high power coal plows and their components. Further perfect and improve hydraulic mining technologies and develop economical hydraulic mining techniques in unstable coal seams where conditions permit, study continuous coal mining technologies and equipment, and work toward domestic equipment production.

Develop new technologies and new techniques for open-cut extraction, work on open-cut slope monitoring and environmental protection technologies. Continue doing good research on deep mineshaft pressures (including bump pressures) and temperature reduction.

4. Further study and improve recovery tunnel support reform technologies. Focus on studying and applying roof bolt and combined roof bolt (stulls, stull mesh, and truss roof bolts) support to replace timber supports and some steel supports. Work on forms, techniques, and materials for roof bolts suitable for use in Chinese coal mines and on high efficiency roof bolt hole drilling and installing machines and tools, perfect and develop inspection and monitoring measures, and do research on

mechanisms and parameter optimization. We also should perfect and develop U-shaped steel and I-beam steel collapsible supports and metallic mesh backplates, and we should develop tunnel side support technologies adapted to the requirements of pillarless extraction techniques.

5. Achieve a basic understanding of technologies for preventing the danger of spontaneous combustion and control terrible accidents. On the basis of gaining a preliminary understanding of the laws of spontaneous combustion for all types of fire hazards in mines, especially deep mines, establish safety and prevention systems and control the occurrence of terrible accidents to achieve safety technology levels that are at international levels of the early 1980's. Further perfect and improve comprehensive prevention technologies for gas explosions and coal and gas eruptions. Improve the properties of drills and work on fast-drilling drill rigs and sealing materials to achieve an obvious increase in gas discharge rates. Do expanded experiments on coal and gas eruption prediction and forecasting, substantially reduce the number of eruptions, and raise speed requirements for eruptive coal seam tunneling and extraction. Study and resolve mechanized extraction technologies for extremely thin extractable coal seams in non-liberated strata. Perfect comprehensive dust control technologies in China's coal mines and combine development of control technologies for comprehensive reduction of dust concentrations with a focus on developing respiratory dust inspection and control technologies. In particular, we should work on prevention and reduction technologies for strong dust-producing and terrible conditions, perfect technical measures for preventing and isolating coal dust explosions, provide new technologies and new equipment for reducing the pneumoconiosis rate and reducing the frequency at which coal dust explosion accidents occur, and continue to develop silicosis prevention technologies.

Perfect and improve comprehensive mineshaft fire prevention technologies, especially prediction and forecasting of spontaneous fires and tunnel open fires, and we should increase the reliability and lifespan of components. Further study fire prevention and extinguishing for roof caving coal extraction and rapid sealing technologies for fire areas. We should also study new technologies and develop new techniques for comprehensive prevention of large fires in surface coal seams in mining regions. We should perfect and improve rescue technology levels. We should reinforce research on water prevention technologies and measures and on integrated equipment mechanization for grouting to block water, flow cutoff, and solidify water isolation strata.

6. Develop coal processing and utilization and environmental protection technologies. Increase the reliability of large jiggers, screeners, and other coal dressing equipment to provide complete sets of large-scale coal dressing equipment that is highly reliable and requires little maintenance. Develop on-line automatic inspection and monitoring and control technologies for coal dressing plants, and increase the quality and recovery rates for cleaned coal. Study large-scale water removal equipment and technologies with good benefits, solve the problem of a high water content in uncleaned coal, and reduce the water content by 5 to 10 percent. Do research on clean coal. Reinforce research on coal desulfurization, perfect physical method desulfurization (inorganic sulfur), and form desulfurization systems with a 120 to 150 tons/hour capacity to reduce the sulfur content of coal by 30 to 50 percent from present levels, and apply them in production. We should also undertake research on removal of organic sulfur. We should do good basic research on integrated coal and oil processing technologies and integrate engineering projects to conduct research on coal-water mixture preparation, pipeline transmission, and combustion technologies. We should achieve industrialization of rapid coal splitting and derive benefits. Continue to do research on comprehensive control and utilization of gangue heaps and make further improvements in technologies for combustion and comprehensive utilization of coal gangue, stone coal, and other low heat value fuels. Improve coal shaping technologies and equipment and undertake research on two-stage furnace gasification and methanization and on tar processing to work on coal gasification in mining regions. Do research on mineshaft water processing technologies and converting it to resources to reduce shortages of coal mine water resources.

7. Perfect and improve haulage and hoisting systems. Further improve single track cranes, clamp track cars, geared track cars, and other mineshaft auxiliary haulage equipment, and in particular improve the reliability of key components. Develop trackless rubber tire haulage equipment and its associated hoisting and other auxiliary facilities to solve short-distance haulage problems. Perfect and improve the reliability of hoist braking systems and electrical control systems and reduce the weight of hoisting containers. Do research on design optimization for mine hoisting and haulage systems and on monitoring, monitoring and control, and microcomputer control.

8. Apply new technologies in coal mines. Use Chinese and foreign-made advanced communications technologies to change the extremely backward communications situation in mining regions and in mines. Do research on using computers for collecting, transmitting, and analyzing data in the production and safety areas, modernize bureau and mine dispatching information, and gradually establish coal industry computer management systems. Develop special types of sensors for use in mines, improve their performance and reliability, and adopt microcomputer technologies to achieve continuous monitoring and centralized control or monitoring and control of the primary links in production. Reinforce applied research in technical economics, systems engineering, and other soft sciences, study wear and corrosion mechanisms and materials engineering for the mining industry, and continue doing basic research on mine pressures, rock breaking, coal breaking, and other mining industry technologies.

B. Main Projects for Extending New Technologies

In conjunction with focusing on extending 100 advanced technologies in the coal industry, we also should focus at present on extending 20 new technologies.

1. New technologies for increasing unit output from blast mining faces. Adopt new millisecond blasting technologies and the three associated technologies of single unit hydraulic props to prevent blast collapses and dual-speed or high power scraper conveyors and supplement them with the corresponding labor organizational management. Experiments in several bureaus (mines) at Xuzhou, Pingdingshan, Fengfeng, and other locations indicate that it can increase unit output and efficiency at work faces by 10 to 30 percent, reduce costs per ton of coal by 10 to 20 percent, improve blasting safety, and improve roof management. Blast mining faces basically should be extended within 6 years, which can increase annual output by 8 to 10 million tons.

2. Adopt new high-grade common extraction matching equipment. Use chainless (or chain) traction double-ended coal shearers, dual-speed side-dumping scraper conveyors, and single unit hydraulic props. Experiments at Feicheng show monthly output of 45,000 tons, which is an increase of 40 percent in unit output and 26.3 percent in efficiency compared to the original high-grade common extraction equipment under similar conditions. It should be extended to 150 faces within 6 years, and projections indicate that face output can be increased by about 5 million tons a year.

3. Use diamond-shaped metallic mesh for roof caving fully mechanized coal mining technologies and slicing extraction of thick coal seams. Roof caving of coal for fully mechanized mining of thick coal seams includes both single-conveyor and dual-conveyor roof caving coal supports. Rather good benefits were obtained in experiments in the Liaoyuan, Yaojie, and Pingdingshan bureaus. In general, monthly output can reach about 40,000 tons, work efficiency is substantially increased, recovery rates are higher, and the amount of tunneling is greatly reduced. Major efforts should be made to extend it in bureaus and mines having the proper conditions, especially in unconventional steeply inclined extra-thick coal seams. Newly developed diamond-shaped metallic mesh is easy to handle, high in strength, and inexpensive. There was an obvious improvement in technical economics results in using it in Hebi Bureau compared to criss-cross metallic mesh and there was a reduction of about 30 percent in metal materials. For this reason, we should make a major effort to extend it in the future in fully mechanized mining of three and more slices or in coal seams extracted through roof caving. There are also definite benefits to extending and applying it in slice mining of coal seams.

4. Sets of equipment for maintenance of single unit hydraulic props. This includes 10 types of special purpose equipment including cleaners and washers, column benders, straighteners, honing machines, testing consoles, and so on as well as electroplating equipment and zinc plating and bonderizing technologies. These types of equipment and technologies form an integrated work line that has a full range of functions for bending, washing, repairing, inspection, and so on. Each set of equipment is capable of repairing 12,000 to 15,000 single unit hydraulic props a year with obvious benefits.

5. Recovery roadway roof bolt support technologies. Xuzhou, Lu'an, and Xinwen have experimented with roof bolt support in recovery roadways. On the basis of different geological conditions and roadway cross-sections, we can adopt terminal bolting or full-length bolting-type single unit roof bolts and integrated roof bolt (stulls, stull mesh, and truss roof bolts) support. Timber roof bolts and bamboo roof bolts can be used along both sides of roadways with additional spreading of timber joist plates and when needed we can also spread sheets of woven reeds and plastic mesh. The results of experimental use have been rather good. It reduces the amount of moving around the tunnels and the cost of support is just 30 to 40 percent that of arched (or stepped) metallic supports and 62 percent that of timber supports. We should gradually extend them in recovery roadways with suitable conditions during the Eighth 5-Year Plan and substantially reduce timber consumption.

6. Technologies for mining coal beneath villages. In conditions of low water tables in thick alluvial strata, use construction of deformation-resistant structure rural houses to enable mining coal without moving villages. Experiments at Yangquan, Xingtai, and Pingdingshan have produced excellent results, and they can be gradually extended and utilized.

7. Hydraulic coal extraction technologies in unstable coal seams. To deal with the geological characteristics and production requirements of unstable coal seams, make rational choices of hydraulic extraction systems and small granularity coal hoisting, secondary layered haulage and transport systems, inclined pipe shallow strata precipitate concentration coal slurry technologies, centrifuge hydraulic control hydraulic guns, machine breaking water-borne tunnelers, water drive axial output local fans, and other new hydraulic extraction technologies and equipment. Excellent technical economics indices were attained in extending them in unstable coal seams and steeply inclined coal seams in Tonghua, Beipiao, and Nanpiao bureaus (mines). Average unit output was 18,000 tons, while productivity and costs were 1-2 times and 43 percent, respectively, of the former non-conventional mining faces. For this reason, developing hydraulic extraction in unstable coal seams is an effective route at present for achieving mechanization of coal extraction.

8. Technical transformation of mine hoisting systems and equipment. Use lightweight skips, lightweight cages, drop prevention devices, and hoist spring valves, and transform electrical protection systems. Utilization in

Xuzhou, Longkou, and other bureaus and mines indicates that this can increase hoisting capacity by 10 to 20 percent and improve safety, so they should be extended in large numbers in transformation of old mines and construction of new mines.

9. Mine leakage communications systems. Using VHF low-band frequencies and relay technologies can achieve radio leakage communications and establish grids with a coverage range of 10 kilometers, and they can be interconnected with mine production dispatching communications systems. The results have been excellent in experimental utilization in Kailuan and Pingdingshan bureaus (mines). They can be widely extended and utilized in mineshaft circulating communications and overhead line locomotive communications and they should gradually be installed in bureaus (mines) with yearly output of 5 million tons and up during the Eighth 5-Year Plan.

10. Mine environment and working conditions monitoring systems. Continue to extend mineshaft environment and working conditions monitoring systems. Mineshaft gas, CO, wind speed, negative pressure, temperature, and other environmental parameters as well as the operating state of electromechanical equipment, coal output, location of coal shearer units, coal levels in coal hoppers, and other production conditions can be immediately transmitted to the surface and the information can be processed and used to display or print out various parameters and tables. They should be gradually installed in high gas and eruptive mines during the Eighth 5-Year Plan.

11. Prevent gas and coal dust explosions and gas eruptions. Continue extending serialization of tunneling work face safety equipment, adopt multi-exhaust borehole pre-discharging rock arch coal exposure, multi-borehole leading pre-discharge hydraulic percussion holes, and deep hole loose blasting, and adopt lattice-type hole deployment in non-liberated strata conditions. Adopt point eruption prediction and forecasting methods and forecasting devices which use drill cutting amounts and gas analysis characteristics as primary diagnosis indices for point eruption prediction and forecasting. They can be gradually extended and utilized in coal mines with the corresponding conditions.

12. Comprehensive mine dust prevention and reduction technologies. Over the past few years, Xinwen and other mining bureaus have employed the principle of rational technical economics in the area of comprehensive dust prevention to attain matching facilities and comprehensive control. They have used water injection into coal bodies, water cannon mud, wet-style hole drilling, water spray sprinkling, dust removal blowers, air flow purification, wet-style shotcreting, blast isolation water troughs, water pockets, and strict monitoring systems to develop dust monitoring. This has greatly reduced the silicosis occurrence rate.

13. Comprehensive mine fire extinguishing technologies. Make major efforts to extend materials as substitutes for yellow mud mortar as well as gangue mortar, powdered coal mortar, and lime mortar to extinguish fires and solve the problem of yellow mud shortages, extend uniform pressure fire extinguishing, inert gas and liquid nitrogen fire extinguishing, and screen leak-stopping fire prevention technologies. Continue to extend beam tube monitoring systems, spontaneous combustion indicator gas fire hazard prediction and forecasting, and portable CO, O_2, and CO_2 fire hazard gas measurers. To prevent combustion accidents caused by electrical cables and belts, we should continue to extend fire-retardant cables. All electrical cables in mineshaft areas should be replaced by the later part of the Eighth 5-Year Plan. In addition, we should give preference to extending and utilizing fire-retardant moving rubber-shielded cables for mine use. We should gradually extend high-strength fire-retardant conveyor belts during the Eighth 5-Year Plan to replace steel wire core rubber conveyor belts and continue to extend and utilize fire-retardant conveyor belts with a tensile strength of 400s to 600s to satisfy coal mine requirements for fire-retardant conveyor belts. To prevent belt accidents, we should gradually match them up with various types of monitoring, control, and protection devices.

14. Utilize pressure filters to achieve closed coal slurry circulation. On the basis of processing capacities in coal dressing plants, adopt pressure filters with a filtering area of 200 m^2, 340 m^2, 500 m^2, and 1,000 m^2. The water content of the product is generally 21 to 24 percent, the filtered liquid is clean, and the average solid content is 0.03 grams/liter, so this is effective equipment at present for achieving in-plant coal slurry recovery and closed cleaning water loops, and they can be extended and utilized in large numbers.

15. Shaped coal processing and utilization. Shaped coal is a fuel which conserves energy and reduces environmental pollution. It has seen substantial development in the past several years. During the Eighth 5-Year Plan, we should make major efforts to extend added modified pulp waste liquid industrial shaped coal and strive to achieve total utilization of 5 million tons. This can reduce coal utilization by about 10 percent and reduce the opacity of smoke by 0.5 grades (Lingeman exponent) and reduce the amount of dust by 60 percent. We also should extend the use of civilian shaped coal for smokeless burning of bituminous coal in the restaurant industry in medium-sized cities and apply technologies to make shaped coal using coal slurry from coal dressing plants in mining regions with the proper conditions to reduce environmental pollution.

16. Coal optimum product structures and rational utilization. On the basis of conducting coal resource surveys, analyzing coal quality characteristics, user surveys, market forecasts, and experiments, establish and utilize coal quality databases to suggest rational coal product structures and technical programs for selective utilization to increase the economic benefits of coal mines.

They have been extended in the Datong, Jincheng, Shenyang, and Yima mining bureaus and in Chongqing Coal Company with rather good economic results. Datong Bureau, for instance, increased its annual profits by 6 million yuan, so it should gradually be comprehensively extended and utilized during the Eighth 5-Year Plan.

17. Two-stage furnace gasification technologies in mining regions. Experiments at Xinwen Mining Bureau's coal gasification station with φ1.6 meter water coal gas two-stage ovens and their technologies indicate that there is a rather wide range of suitable coal varieties ranging from old lignite to long flame coal, weakly bonded coal, unbonded coal, gas coal, poor coal, and lean coal that can all be used. The technology and operations are simple and it is a gasification method which uses normal pressures and requires no oxygen. The heat value of the coal gas is rather high, generally about 2,500 kcal/Nm^3. The furnaces are small and require few investments and all of them are Chinese-made equipment. Thus, they are suitable for wide extension and utilization in medium and small cities and towns in mining regions.

18. Sounding technologies for small geological structures in mines. These are used mainly for leading sounding ahead of coal tunnel and rock tunnel tunneling bits and for sounding along the sides, roofs, and floors of roadways. This includes the use of mine geology radar at Kailuan, Ganlang, Jiaozuo, and other bureaus and mines, which received effective signal distances of more than 30 meters during sounding with rather good geological benefits. The sounding distance attained advanced levels of similar types of international instruments. After repeated improvements, we have over 10 years' experience in using the pit perspective method and the perspective distance is generally up to 230 meters. We have conducted experiments with digital slot wave seismometers on 19 work faces in 13 mines with a success rate of 76 percent. The transmission distance is 600 meters and the reflection distance is 100 to 150 meters.

19. Back-shaft drill rigs. These have been used to complete over 30 shafts in nearly 10 bureaus (mines) including Kailuan, Jixi, and others to drill a total of more than 2,000 meters with obvious results. The shaft completion rate is high, with an average monthly driving footage of 100 to 150 meters, work efficiency is increased 3- to 4-fold, and it conserves about 80,000 yuan in investments per 100 meters of back-shaft drilled. Especially noteworthy is the operational safety and low labor intensity. We have φ1/2 meter, 1.5 meter, 1.8 meter, and 2.0 meter series, and they can be extended and utilized in large numbers in construction of hidden shafts, in-shaft coal hoppers, and extended depth shafts.

20. Blast-resistant hydraulic braking downward-hauling belt conveyors. These conveyors are suitable for use in downward transport of raw coal in upward mining in coal mines with gas and coal dust explosion hazards. There hydraulic braking systems can achieve stable braking. The drive rollers have a rubber jacket with a high friction coefficient and they have speed increasing and reduction protection, runaway, overload, full coal hopper, and various other protection devices and multiple machine drive power stabilizing devices to ensure safe operation of the downward-hauling conveyors under conditions of 16° angles. They can play a substantial role in reducing the amount of shaft engineering. They are now being extended and utilized in several mines.

III. Policies and Measures

A. Reliance on Technical Progress Should Be the Primary Content for Examination of Comprehensive Contractual Responsibility in the Eighth 5-Year Plan

The following indices of reliance on technical progress and transformation of the technical situation should be included among the content of examination of comprehensive contractual responsibility during the Eighth 5-Year Plan: the extent of mechanization in excavation, the death rate per 1 million tons, the occurrence rate of pneumoconiosis, full-staff efficiency, the ash content of commodity coal and washed coal, coal recovery rates, dimensions of opening, the completion rate for equipment renovation and transformation, the completion rate for extension of projects to attack key S&T problems and projects to extend new technologies, the employee training situation, and so on. The China Unified Distribution Coal Mine Corporation should set annual examination indices and reward and punishment requirements on the basis of mining bureaus.

B. Establish Stable Coal S&T Development Funds

Beginning in 1990, the China Unified Distribution Coal Mine Corporation should deduct 0.1 yuan per ton of coal to serve as a coal S&T development fund under unified control by the corporation and mainly used for projects to attack major S&T problems. We should implement deduction of 1 percent from costs on the basis of sales volume as a technical development fund to expand pilot plant enterprises, and we should provide a sufficient amount and use these funds well. We also should strive to further expand the scope of pilot plants.

C. Reinforce the Strengths of Enterprises in Relying on Technical Progress

On the basis of State Council Report No 21 (1985) approved by the State Council and transmitted to the State Economic Commission concerning the promotion of technical progress in enterprises and "Provisional Stipulations Concerning Promoting Technical Progress in Enterprises," and the notice "Provisional Stipulations by the Ministry of Coal Industry Concerning Certain Policies To Promote Technical Progress in Enterprises" issued in Ministry of Coal Industry Coal Technology Document No 886 (85), feasibility research on new mining region (as well as mine and plant) construction projects should include clear requirements concerning major S&T research tasks in construction and the scientific research tasks proposed should be included in

preparatory projects for construction projects. The necessary scientific research funds should be provided by the corresponding project capital construction investments. Construction units should deduct 10 percent from their retained profits or renovation and transformation funds for use as technical development funds. Equipment depreciation funds should be mainly used to renovate equipment and develop mechanization. The 10 percent S&T development fund deducted from contractual responsibility allocation funds in production enterprises should be used to provide sufficient equipment depreciation funds for use in equipment renovation and developing mechanization. Geological exploration units should deduct no less than 1 percent per year from their geological operations fund for use as a technical development fund.

Strive to implement interest-free and low-interest loans from the state for use in developing mechanization and transforming the safety technology situation in coal mines to enable faster technical transformation in coal mines. Strive to implement the method of including coal mines which mine coal in difficult circumstances (including "three beneaths" coal, leftover coal, coal seams with coal and gas eruptions or serious bump pressures, thin coal seams which are below the minimum extractable thickness, and other non-economical recoverable reserves) in the unified distribution system with output guarantees and negotiated prices.

D. Reinforce Scientific Research Experiments and Construction of Quality Supervision and Inspection Facilities

Capital construction funds and the required foreign exchange should be maintained at no less than existing levels in the Seventh 5-Year Plan for use in preferential construction of key laboratories and installing the required large-scale precision instruments and equipment to solidify, reinforce, and improve scientific research working and living conditions in scientific research units, perfect and improve existing state-level and ministry-level product quality supervision and inspection centers, and gradually build the related engineering and environmental quality supervision and inspection centers. Reinforce attributable management of coal industry quality supervision and inspection and professional construction of state-level and ministry-level quality supervision and inspection centers to ensure certification, scientific qualities, and authoritativeness, to achieve correct inspection databases and scientific and reliable conclusions. Strictly implement enterprise upgrading, product upgrading, new product inspection and approval, and other policies linked to quality supervision and inspection.

E. Increase Investments in Knowledge, Absorb Talented Personnel, Improve Employee Quality, and Stabilize Employee Staffs

Adopt policies to encourage students to apply to coal academies and engage in coal mine work. Students in coal education institutes should be given scholarships with better treatment and S&T personnel working in the coal industry should receive more preferential wage treatment. On the basis of summarizing existing hiring systems and wage policies, formulate hiring systems and wage policies conducive to technical progress in the coal industry, especially hiring systems and wage policies for key jobs. We should use coal mine technical school graduates as a source of workers for key jobs, reinforce training for workers, especially those in key jobs, and try to improve living and welfare facilities for coal mine employees.

F. Do Good International S&T Cooperation and Exchanges

Use all types of channels and adopt all types of arrangements to establish long-term and stable international S&T cooperative research and technical exchanges, and assign superior quality comrades directly involved in S&T work to participate in this line of work.

Development, Prospects of Coal Industry

906B0075A Beijing SHIJIE MEITAN JISHU [WORLD COAL TECHNOLOGY] in Chinese No 4, Apr 90 pp 6-8

[Article by Fan Weitang [5400 4885 0781], assistant general manager and professor-level senior engineer in the China Unified Distribution Coal Mine Corporation: "Development and Prospects of China's Coal Industry"]

[Text]

I. Development of China's Coal Industry

Our coal industry has made enormous achievements in the 40-plus years since the nation was founded. Raw coal output rose from 32.43 million tons shortly after the nation was founded in 1949 to 1.04 billion tons in 1989, of which 459 million tons was produced in unified distribution coal mines, 205 million tons in local state-run mines, and 336 million tons in township and town enterprise and local mines. We have also carried out large-scale coal mine construction. We have completed 16 large mining regions with yearly output in excess of 10 million tons and 13 medium-sized mining regions which produce 5 to 10 million tons annually, and we have formed 131 coal production base areas which integrate large, medium, and small scales.

Reliance on scientific and technical progress to promote modernized construction in the coal industry is an important principle in the development of China's coal industry. China's multi-level coal mine structure determines a multi-level technical development strategy. For a rather long period of time, the level of technical equipment in the coal industry will be a technical structure that combines modernization, mechanization, and semi-mechanization in an effort to attain advanced world levels. For the past 10 years, we have focused on building 77 modernized mines and modernized mining regions and completed 30 mines and four big mining

regions at Lu'an, Jincheng, Yanzhou, and Xingtai by 1989. Work on them will continue in a gradual fashion according to plans in the Eighth 5-Year Plan and construction of modernized mines and mining regions will continue into the future.

Local state-run mines have mainly focused on common mechanization and semi-mechanization. Township and town coal mines will use technical transformation to achieve conventionalized production.

In the area of mine construction: Freeze sinking has now been used at 240 sites in coal mine construction with a maximum freezing depth of 415 meters and maximum shaft diameter of 8 meters. Shaft sinking methods have been used in 35 shafts with a maximum depth of 508 meters and maximum diameter of 9 meters. Sunk shaft sinking methods were used at 118 sites with a maximum shaft depth of 193 meters. Curtain method sinking has been used to sink 23 shafts to a maximum depth of 57 meters. Tunnel smooth blasting shotcreting techniques are in wide use and over 1,000 kilometers of rock tunnels have been sunk each year using smooth blasting shotcreting technologies.

In the area of extraction techniques: In coal seams with suitable conditions, we are shifting from strike longwall mining to inclined longwall mining to reduce the amount of engineering and increase economic benefits. Extending pillarless extraction methods is an important technical measure to increase recovery rates, increase tunneling rates, reduce tunnel protection expenses, and increase economic benefits. To increase output from fully mechanized mining, reduce the number of moves, shorten moving schedules, and take full advantage of the efficiency of fully mechanized mining, we are using reciprocating extraction with obvious economic benefits. Hydraulic coal extraction in unstable coal seams and coal seams with major variations in thickness is an effective mining method. Experiments in full-height extraction of 3.5 to 4.5 meter-thick coal seams in one pass were successful and they solved the problem of full-thickness extraction in thick coal seams. We are also experimenting with roof caving to extract coal in 6 to 10 meter-thick coal seams and have made preliminary achievements. Many of China's coal fields are beneath railways, bodies of water, and structures and contain large suspended coal reserves. We have now extracted over 600 million tons of coal with special "three beneaths" extraction techniques. We have extracted 30 million tons a year for the past several years and accumulated rich extraction technique experience and a theoretical foundation.

In the area of developing comprehensive mechanization: Based on coal seam endowment conditions in China, we have developed complete sets of fully mechanized mining equipment which can mine gently sloping coal seams at extraction heights from 1.0 to 4.5 meters, complete sets of fully mechanized mining equipment for caving extra-thick coal seams, and complete sets of fully mechanized mining for mechanized spreading of floor nets to extract thick coal seams layer by layer. These sets of fully mechanized mining equipment that now have formed model series are being widely used in China's coal mines and they have achieved excellent economic results in increasing unit output at coal mining faces. Mine extraction technologies have been raised to a new level. There were 26 fully mechanized mining teams which produced over 1 million tons in 1988. The No 1 fully mechanized mining team at Gushuyuan Mine in Qincheng Mining Bureau used a Chinese-made complete set of equipment to produce 1.8 million tons in 1 year and set a record in China. Four fully mechanized mining teams at Wangzhuang Mine in Lu'an Mining Bureau exceeded the 1 million ton level. Yearly mine output of 5 million tons and a full-staff efficiency of 5.4 tons/manshift made it the first entirely fully mechanized mine in China.

In the area of safe production: In the area of gas prevention, we have experimented successfully with several types of gas extraction techniques with excellent applied results. In mines with the danger of coal and gas eruptions, we have employed extraction of liberating strata, pre-extraction of gas, leading boring discharging, deep-hole loose blasting, hydraulic piercing, and other techniques with definite results. We have now begun using coal and gas eruption forecasting and reporting techniques in producing mines. In the area of mine fire prevention techniques, we have used spontaneous combustion retardant techniques, equal-pressure ventilation, high-multiplication bubbling, inert gas extinguishing, and other techniques in production.

Electronic computers are being used to optimize mine ventilation with excellent results. We have extended and utilized tunneling work face extraction-type ventilation technologies, comprehensive dust prevention, and gas and coal dust explosion isolation technologies. Definite results have been achieved in scientific experiments on mine temperature reduction. In the area of safety monitoring, we have extended many types of gas telemeters, gas alarm power shutoff devices, portable gas alarms, and multifunction mine safety monitoring systems.

In the area of coal dressing and comprehensive utilization, we now have the capability of manufacturing large coal dressing plants and technical equipment with a yearly processing capacity of 3 million tons of raw coal. We also have successfully developed heavy medium rotary flow devices, spray flotation machines, large automatic presses, high efficiency screening equipment, and so on.

In the area of comprehensive coal utilization and conversion, low heat value fuel fluidized bed combustion technologies are now in wide use at pit-mouth power stations in mining regions. Coal gangue and stone coal used to make construction materials, shaped coal, and so on are now being applied in production. High efficiency coal gasification and direct liquefaction technologies are now being studied and developed. We have obtained

excellent results with coal-water mixture preparation and combustion experiments.

II. Prospects and Primary Technical Measures for the Coal Industry in the Year 2000

Coal accounts for over 76 percent of China's energy resource consumption structure and the proportion of coal in the energy resource structure is not expected to change for quite some time to come. As China's national economy develops, demand for coal will continue to grow and is expected to reach 1.4 billion tons in 2000. Several modernized coal mines will be built during this period. The degree of mechanization in unified distribution coal mines is expected to reach 76 percent by the end of this century and there will be noticeable improvements in full-staff productivity and safety conditions. Some key coal mines will reach advanced international levels for that time and technical transformation will be carried out in local coal mines to raise technical levels. To meet the needs for developing the national economy, we will continue to reinforce coal mine construction and build several new mines and strip mines. We also will carry out technical transformation in existing producing mines and increase production capacity to promote development of the coal industry and resolutely rely on scientific and technical progress. The main measures are:

A. Accelerate Coal Mine Construction, Expand the Scale of Extraction, Increase Design Capacity

To meet the need for coal to develop the national economy, we must rely on S&T progress, adhere to the principle of integrating large, medium, and small scales, make rational deployments, reform coal mine designs, improve construction technologies, adopt new technologies and new techniques, reduce construction schedules, and increase design capacity.

Strip mining is one direction for development of technology in China's coal industry. We should give preference to developing open-cut mining in coal fields with suitable conditions where the costs would not be higher than extraction using shaft mines. Concentrate forces to develop strip mines with good conditions like Anjialing and Antaibao No 2 at Pingshuo, Jungar, Yiminhe, and so on. Strip mining techniques and technical equipment should be based on coal seam endowment conditions and China's technical equipment manufacturing capabilities to make rational choices of extraction techniques with advanced technologies and good economic benefits.

Accelerate new mine construction. We first of all should reform designs. Coal mine designs should adhere to the principle of centralization, mechanization, and economic rationalization to optimize mine opening deployments, rationally centralize production, and reduce tunneling rates. In general, there should be no rock tunnels and more coal tunnels in mining regions. We should reduce construction schedules, conserve investments, and attain full output quickly.

Improve mine construction technologies. Rely mainly on common shaft sinking and drilling-blasting methods, adopt large pit cars, large buckets, large rock loaders, large drill rigs, heavy rock borers, and other matching equipment. We should improve matching and increase reliability.

When the thickness of surface layer alluvium is less than 100 meters, we should adopt sunk shaft method or screen method shaft boring technologies in adaptation to local conditions. When it is more than 100 meters thick, we should employ the freezing method or shaft boring method. The shaft boring method is one development direction for future shaft sinking technologies. We should quickly improve existing shaft boring technologies and work on supports to prevent and correct slanting, backwall filling, and other technologies. In the area of freeze sinking, we should reinforce attacks on key problems with freezing technologies in shafts 400 to 600 meters deep, solve problems with rapid vertical drilling of freeze boreholes in deep shafts, prevent fracturing of freezing pipes, and perfect compound shaft wall support technologies.

Perfect rock tunnel tunneling, improve full sets of mechanized work lines with boring, loading, haulage, and roof bolting centered on side-dumping rock loaders or drill loaders, and improve existing shotcreting technologies.

B. Carry Out Technical Transformation and Increase Production Capacity in Existing Producing Mines

Using advanced S&T for technical transformation in existing mines with suitable conditions is an important principle in developing the coal industry. The goal of technical transformation is to increase output and efficiency, improve safety conditions, increase economic benefits, change the technical situation in coal mines, and achieve coal mine modernization.

1. Make a major effort to develop mechanization, increase unit output and unit tunneling rates, and achieve mine shaft centralization

Mine mechanization mainly involves extraction, tunneling, and haulage. Adopt fully mechanized mining, high-grade common mining, hydraulic mining, and so on according to production and geological conditions.

Fully mechanized mining and fully mechanized tunneling should first of all be installed in newly built large mines or mines where there has been technical transformation which have suitable conditions. In a large mine with yearly output of 2 to 3 million tons due to improvements in unit output and unit tunneling rates, use just two or three fully mechanized mining faces and fully mechanized tunneling faces to guarantee yearly output in the mine and achieve centralized mine production. We also should perfect and improve the reliability, applicability, and economy of existing sets of fully mechanized extraction and fully mechanized tunneling equipment. Continue to develop and perfect full sets of equipment for large slope angle coal mines, thick coal seams, and

thin coal seams. We should develop complete sets of fully mechanized mining equipment with a daily output capacity in the 10,000 ton grade and associated technologies to meet the needs of the high output, high efficiency mining faces. Hydraulic coal mining technologies are suitable for mining steeply inclined coal seams and unstable coal seams. We should continue to develop single-track cranes, blocked track carts, geared-track carts, and other auxiliary mineshaft haulage equipment suited to conditions in Chinese mines.

2. Perfect and improve extraction technology levels

a. Further develop extraction techniques and technical equipment for one-pass full-height extraction of 3.5 to 4.5 meter-thick coal seams, mechanized net spreading seam-by-seam extraction technologies for extra-thick coal seams, roof caving coal extraction, and so on.

b. Substantial coal resources lie beneath railways, bodies of water, and structures in China. We should focus on research on rational programs and technical routes to mine coal beneath villages to enable extraction without moving villages when conditions are suitable.

c. In coal seams with suitable conditions, employ reciprocating extraction techniques and adopt space-following, tunnel-leaving, pillarless extraction techniques and tunnel-side support techniques to enable rapid moves of fully mechanized mining equipment, reduce the number of moves, and reduce tunneling rates.

d. Study small structure sounding methods and instruments, grout injection cutoff technologies, and water-resisting layer pressure bearing mining techniques for China's coal seams with karst water threats to solve problems in safe extraction of our substantial coal resources beneath Ordovician karst water threats.

e. As mines gradually develop toward greater depths, ground pressures increase, there is more gas, and temperatures are higher. We should focus on studying and solving tunnel deployments and support technologies in deep parts of mines and in soft rock conditions and improve all types of support technologies.

3. Carry out technical transformation and normalize production in township and town collective coal mines

Apply appropriate technologies for technical transformation in small township and town coal mines, reform coal extraction methods, increase recovery rates, extend and apply metallic friction supports, use bendable scraper-trough conveyors, and implement blast-fractured coal loading to increase unit output. Powered single work lines should be used in rock tunnel tunneling and we should implement small-scale mechanization of tunneling.

C. Improve Safety Measures, Improve Mine Fire Resistance Capabilities

1. Gain a better understanding of the laws of water, fire, and gas, eruptions, dust, ground temperatures, roofs, and other natural dangers, study and resolve detection, forecasting, prediction, and prevention techniques for all types of dangers.

2. Apply high reverse-pressure concentrated hole discharge methods, increase gas discharge rates, study and resolve single coal seam gas discharging and improve coal, gas, and carbon dioxide eruption technologies.

3. Deal with dust prevention technologies for mining and tunneling work faces, shotcreting work points, and working under terrible conditions, perfect existing comprehensive dust control technologies, perfect and improve comprehensive mineshaft fire prevention technologies and comprehensive control technologies for mineshaft high ground temperatures.

4. Increase safety technical equipment levels, form safety, inspection, monitoring and control, and alarm technologies at different levels.

D. Develop Coal Processing and Comprehensive Utilization

1. Perfect research on rational coal screening and utilization in China's main mining regions, optimize the coal product structure. Raise equipment levels and automation technologies in existing coal dressing plants.

2. Resolve recovery technologies for inorganic sulfur recovery in different coal types and different embedded granularities, study high sulfur coal utilization and organic sulfur removal technologies.

3. Improve low heat value fuel and high sulfur coal fluidized bed combustion technologies, rationally utilize low heat value fuels to improve the environment.

4. Develop civilian coal gas technologies for medium-sized and small cities in mining regions to solve the gas supply problems of residents in large and medium-sized mining regions and medium-sized and small towns.

5. Develop technologies to utilize gas, diatomaceous earth, and so on.

It is a basic national policy in China that the coal industry should continue to open up to the outside world and reinforce technical cooperation. To accelerate the pace of technological development in China's coal industry, we will continue to import key technical equipment which we cannot produce within China for the time being to compensate for the absence or shortage of certain technologies in China. At the same time, we will continue to undertake technical and economic cooperation with certain countries and strive to raise the technical situation in China's coal industry to a new level.

Achievements, Outlook of Coal Mining Technology

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[Article by Yin Jichang [3009 4949 2490], director of the China Unified Distribution Coal Mine Corporation Production Bureau and professor-level senior engineer: "Achievements and Prospects of China's Coal Mine Production Technology"]

[Text] Under the correct leadership of the CPC Central Committee and State Council over 40 years since the nation's founding, raw coal output in China has increased substantially, rising from 32.43 million tons in 1949 to 1.04 billion tons in 1989, an average yearly increase of 25.19 million tons. This makes China one of the world's leaders in raw coal output. Major changes have occurred in coal mine production technologies over the past 40 years. This is particularly true since the 3d Plenum of the 11th CPC Central Committee, when the coal industry has adhered to a focus on reform and opening up to improve economic benefits and conscientiously implemented the strategic principle of "economic construction must rely on scientific and technical progress, S&T must be oriented toward economic construction." We have focused on fostering the enormous role of S&T, adhered to the principle of technical transformation, made great efforts to develop mechanized excavation, accelerated construction of modernized mines, intensively developed "quality standardization and creating safety levels" activities, and shifted coal production onto a new technological foundation, which have brought substantial improvements in production, safety, technology, and management levels in the coal industry.

I. Reliance on S&T Progress Has Brought Major Changes to Coal Mine Production Technologies

For the past 10-plus years, China's unified distribution coal mines have used technical transformation in mines and major efforts to develop fully mechanized coal mining and mechanized tunneling which have effectively promoted improvements in coal production levels and accelerated coal mine transformation and the pace of modernized mine construction. The good situation in coal production at the present time is the result of S&T progress over the past 10-plus years and especially the development of fully mechanized mining. Just as Comrade Deng Xiaoping pointed out 10 years ago, "Fully mechanized mining should be considered a development goal and an important technical policy and development principle. Developing fully mechanized mining is not simply a question of increasing output. It changes the entire situation in coal mines. However, it does not provide a fundamental solution to the safety problem, pneumosilicosis problem, or low efficiency problem." Practice over 10-plus years has proven that this thesis conforms to reality in coal mines.

Reliance on S&T progress has brought profound changes in production, technology, management, and other areas in China's unified distribution coal mines. These are manifested mainly in eight areas:

1. Sustained stable growth in coal output. There has been sustained and stable growth in raw coal output at China's unified distribution coal mines for 8 years since 1982. Output has grown by almost 120 million tons since 1981. This substantial increase in raw coal output over this period of time and the length of time of sustained growth are unprecedented in the history of China's coal industry and have contributed substantially to development of the national economy.

2. There has been a significant increase in the degree of mechanized excavation and fully mechanized mining has been an important way to increase output. With approval by the CPC Central Committee and State Council, we imported 43 sets of fully mechanized mining equipment from foreign countries in 1973 and 100 sets in 1978. We also imported 100 single tunneling units and decided to manufacture the associated fully mechanized mining equipment in China. This played a major role in promoting development of mechanized excavation in China's unified distribution coal mines. The degree of mechanization in China's unified distribution coal mines reached 60.94 percent in 1989. This included a fully mechanized mining extent of 33.31 percent and a mechanized tunneling loading and dumping extent of 55.53 percent, both of which were up substantially over 1975. The degree of mechanization in China's unified distribution coal mines exceeds 70 percent in 21 mining bureaus and 90 percent in 10 mining bureaus. Output from fully mechanized mining in China surpassed 122.53 million tons in 1989. During this period, stope output in China's unified distribution coal mines increased from 234.59 million tons in 1975 to 350.36 million tons in 1988, an output increase of 115.77 million tons. Of this amount, reliance on fully mechanized mining accounted for 88.4 percent of the total increase.

3. Transformation and exploitation of potential in old mines has increased comprehensive production capacity in mines. Since 1976, reliance on S&T progress in China's unified distribution coal mines has led to planned and focused transformation, expansion, and exploitation of potential in producing mines. During the 10-year period between 1976 and 1985, transformation was carried out in 328 shaft mines (and strip mines). This included expansion of 81 mines which increased their design capacity from 63.51 million tons to 126.27 million tons and construction of 62.76 million tons. Regular technical transformation was carried out at 247 mines at a construction scale of 21.31 million tons. Most of the mines where technical transformation was carried out increased output. This included an output increase of 65 million tons in Shanxi, Shandong, Henan, and Heilongjiang provinces. Among existing mining bureaus with yearly output over 10 million tons, Kailuan,

Datong, Yangquan, Xishan, Lu'an, Jincheng, Pingdingshan, Huaibei, Fengfeng, Xuzhou, Jixi, Hegang, and Xinwen bureaus as well as mining bureaus which will achieve 10 million tons like Yima, Shuangyashan, Tiefa, and others were developed by relying mainly on this route to become key state coal production base areas. Moreover, Fenxi, Qitaihe, Zhengzhou, Songzao, Hebi, Xingtai, Shizuishan, and other bureaus also substantially increased their coal output. Technical transformation in Tonghua, Beijing, Jiaozuo, Zibo, Xinglong, Beipiao, and other old mining regions played an important role in stabilizing production and slowing delaying reductions.

4. Rational centralization of production changed traditional backward coal mining techniques. Technical progress has led to greater centralization of mine production. There have been obvious changes in the past situation of small shafts, high density of entrances, scattered production, large numbers of horizontal extraction areas, and long battlelines. In the 1960's and 1970's, average yearly output per shaft in unified distribution coal mines was 400,000 to 500,000 tons, but it had grown to 700,000 tons by 1989. There are 149 mines with yearly raw coal output in excess of 1 million tons that have a total output of 268.65 million tons, equal to 61.8 percent of output from unified distribution coal mines. They are a primary force in stable output increases. Mines under construction and undergoing expansion have adhered to the principle of rational centralization of production and increased the size of faces and the length of mining area strikes. This has brought relative concentration of faces, mining areas, and production levels, simplified production links, and increased overall production capacity.

By using new technologies and equipment, we have successfully experimented with eight types of coal mining techniques in recent years: 1) Permanent floor upward-moving slicing, which has solved the problem of extracting thick coal seams, soft coal seams, and roofs with high water contents. 2) Fully mechanized overhead, downward, and inclined extraction has solved problems with the difficulty of using fully mechanized mining in complex geological structures. 3) Fully mechanized rotary extraction has extended the length of thrust extraction, reduced the number of moves, increased production time, and raised recovery rates. 4) The results of fully mechanized mining using horizontal slicing roof caving for steeply inclined coal seams have been quite good. 5) Fully mechanized coal mining by opening roof lights and caving in gently inclined thick coal seams has reduced tunneling rates and materials consumption per 10,000 tons. 6) Experiments with single-pass full-height fully mechanized mining of 5 meter thick gently inclined coal seams have been successful, and it conserves a great deal of tunneling and simplifies production systems. 7) Experiments with fully mechanized mining of hard roofs and coal seams have also been successful. 8) New techniques for mining "three softs" coal seams have laid a foundation for using fully mechanized mining in "three softs" coal seams.

There have also been substantial developments in new opening and tunneling techniques and technologies. Examples include the common extension and application of coal and semi-coal tunnel tunneling work lines, rock tunnel hydraulic drill rig work lines, new types of open blasting shotcreting techniques and technologies, U-shaped collapsible steel supports, metal net back plates, temporary supports for tunneling drill bits, hole-following tunnel transmission, hole-following tunnel-leaving technologies, and so on, which have played an important role in raising the degree of mechanized tunneling and accelerate tunneling rates.

5. There have been substantial increases in unit output, unit driving footage, and labor productivity. Stope face unit output in China's unified distribution coal mines increased from 9,658 tons/month in 1975 to 14,802 tons/month in 1988, an increase of 5,144 tons/month. Since 1985, we have completed a transition from increasing output, increasing faces, and increasing personnel to increasing output, reducing faces, and reducing personnel. The number of stope faces was reduced by 247 from 2,341 in 1985 to 2,094 in 1988. Calculated on the basis of 1975 stope face unit output and shift productivity, this is equivalent to a reduction of 100,000 stope workers. This was mainly the result of developing mechanized coal mining and especially the role of fully mechanized mining.

The development of mechanized tunneling has increased unit driving footage. Overall unit driving footage in tunneling in China's unified distribution coal mines in 1989 reached 115.4 tons/month. Yearly mechanized tunneling dimensions averaged 3,342 meters and the highest was over 10,000 meters.

Reliance on S&T progress has greatly increased full-staff raw coal productivity, reduced materials consumption, and increased economic benefits. Full-staff raw coal productivity in China's unified distribution coal mines surpassed 1 ton/manshift in 1986 and reached 1.157 tons/manshift in 1989. Stope shift productivity reached 5.594 tons/manshift, an increase of almost 2 tons/manshift over 1975. Raw coal pit timber consumption dropped from 130 cubic meters/10,000 tons in 1975 to 39.49 cubic meters/10,000 tons in 1989.

6. Substantial improvements have been made in safe production conditions. Application of advanced safety monitoring and control equipment and increases in the degree of mechanized excavation have brought the happiest tidings, safety, to coal mine workers. Reforms in excavation face supports have improved working conditions for miners. This is particularly true of fully mechanized mining which has substantially reduced roof accidents. According to statistics, the death rate for fully mechanized mining faces from 1974 to 1988 was 0.48 per 1 million tons, a 70 percent reduction compared to blast mining and common mining faces. In the area of electromechanical mine equipment, reliance on S&T progress has improved hoisting systems, perfected mineshaft electrical protection and belt protection, improved

ventilators and water pumps, and guaranteed safe and economic operation of equipment. For mineshaft transport, installation of inclined shaft personnel haulers and horizontal tunnel personnel haulers, and installation of special explosion-preventing electric-powered carts in high methane and "two eruptions" [coal and gas] mines have improved the mine transportation safety environment and workers' labor conditions.

7. We have trained staffs and improved the quality of cadres and workers. After more than 10 years of practice, China's unified distribution coal mines have accumulated many successful experiences in staff technical training, reinforcing on-site production technology management, undertaking level-setting activities in excavation teams, and other areas and many excavation teams with high technical levels and good quality have appeared.

8. We have extended and applied modernized enterprise management methods. Examples include management by goals, comprehensive quality management, value engineering, and application of electronic computers, which have gradually formed modernized management measures. We have initially established several modernized bureau mines that have established models for modernization of China's coal industry. Since 1984, key unified distribution mines have speeded up establishment of modernized mines which have primary indices of high efficiency, good safety, fewer personnel, good quality, good benefits, and continual improvement of employee living conditions. Lu'an Mining Bureau has taken aim at advanced international levels and used development of fully mechanized mining as a key aspect and excavation and haulage as a focus for comprehensive promotion of technical progress and modernized mine construction, and they have established China's first modernized mining bureau. Their raw coal output reached 10 million tons in 1988 and they have entered the ranks of extra-large scale coal enterprises. The level of mechanization in coal mining has been maintained at 100 percent, the degree of fully mechanized mining at 99.2 percent, and the degree of fully mechanized excavation at 50 percent. They have held first place in China in full-staff productivity for many years in a row. The bureau had a total of 23,000 employees in 1988 and its full-staff efficiency was 4.209 tons/manshift. Jincheng Mining Bureau is a good example of relying on one's own efforts to build modernized mine bureaus. For several years, they have adhered to the path of relying on technical progress, exploiting internal potential, and raising their own capital to develop mechanized excavation to push the degree of mechanization in coal extraction up to 100 percent, including a fully mechanized mining level of 88.1 percent and a degree of mechanized excavation of 43.8 percent. Raw coal output in the bureau reached 10.03 million tons in 1988. They had 22,000 employees, a full-staff efficiency of 4.202 tons/manshift, and a death rate of 0.217 per 1 million tons. Yanzhou, Xingtai, Datong, Pingdingshan, Xuzhou, Fengfeng, Qitaihe, and other mining bureaus have also made good achievements in modernized construction. So far, eight of China's unified distribution coal mines at Lu'an, Jincheng, Yanzhou, Xingtai, Datong, Xishan, Yangquan, and Longkou have been designated as modernized mining bureaus and modernized mines. There are 27 enterprises which have been promoted to state second-level enterprises and 73 mines, plants, and sites which have been promoted to coal industry second-level enterprises.

Of course, it must be acknowledged that although technical progress has developed very quickly over the past 10-plus years in China's unified distribution coal mines, there are still many problems and lessons. The low levels of technical equipment, low personnel quality, low efficiency, poor results, and lack of a basic change in safe production in unified distribution coal mines mean that we still lag quite far behind advanced levels in foreign countries. We must have a clear understanding of this.

II. Primary Routes and Experiences in Developing Coal Production

We have accumulated rather rich experience in the area of relying on S&T progress to develop coal production over the past 10-plus years. Concretely speaking, it covers these five areas:

A. Resolute Efforts To Develop Mechanized Excavation Is the Basic Way To Develop Coal Industry Production

Mechanized excavation is the key to promoting total mine mechanization and modernized construction, and it is the direction and a concentrated embodiment of S&T progress in coal mines. Many mining bureaus have accumulated very good experiences in the area of developing mechanized excavation. In essence, they cover the following points:

1. Attention from leaders, profound understandings, healthy structures, and level-by-level responsibility are the guarantees for developing mechanized excavation. Leading cadres at all levels must understand that developing mechanized excavation is a strategic measure for developing production to be able to more correctly solve the relationship between the present and the long term and actively create the conditions for developing mechanized excavation. All bureaus and mines which have developed mechanization rather quickly have three characteristics: 1) A focus by primary leaders; 2) administration by specialized departments; and 3) large numbers of men of action who are enthusiastic about mechanization. Mechanization has proceeded fastest over the past several years in Shanxi, Shandong, Hebei, Henan, and other provinces, and in Datong, Pingdingshan, Lu'an, Jincheng, Xingtai, Yanzhou, Fengfeng, Xinwen, Xishan, Hegang, Qitaihe, and other mining bureaus. One important experience in them is attention from the leadership and implementation of responsibility.

2. Scientific debate. Rational selection of models according to mine geology conditions and adherence to equipment standardization and systemization are

important experiences in successful operationalization on the first attempt in mechanized excavation. All units which solved these problems well have had good results. The opposite is true for those which did not. Thus, the need for "careful model selection and devotion to reason" according to geological conditions is certainly an important experience.

3. Implementing scientific management is an important way to foster the full effects of mechanized excavation. Practice has proven that bureaus and mines which have focused strictly on management and have a mature set of methods can gain better benefits in mechanized excavation. The focus is on matching administration to concentrate on the goal of guaranteeing normal replacement of fully mechanized mining and mechanized tunneling faces and on-site management concentrated on improving engineering quality and equipment completeness. All high output teams and rapid teams achieved level-setting goals by relying on scientific management.

4. Doing good technical training work and continually raising cadre management levels and worker technical and operation levels is the basis for fostering the benefits of mechanized equipment. All bureaus and mines which have developed mechanized excavation more quickly have paid extremely close attention to staff training. They have focused on establishing fully mechanized mining and mechanized tunneling staffs. They have worked on theoretical training and operational training prior to startup and achieved the "three understands and four knows." They have done good tracking training after startup and raised worker technical and operating levels during practice. They have done good contingency training before and after equipment replacement. They have done good training for new workers. They frequently undertake post drill, technical skill competitions, and other activities, carry out scheduled testing of the five main job categories, establish test and training archives, and so on to promote continual improvements in staff quality.

5. They reinforced unified management of equipment and established rear base areas for mechanizing excavation, mainly leasing centers and inspection and repair centers, which are important measures for developing mechanized excavation. Implementing equipment leasing raised equipment utilization rates, speeded up equipment reclamation and installation, and accelerated equipment turnover. Practice at Yanzhou, Xishan, Yangquan, and Datun has proven that this is a good experience.

6. They developed mechanized excavation and established multi-level mechanized coal mining technology structures of various forms according to the principle of adapting to local conditions oriented toward fully mechanized mining and focused on high levels. Many mining bureaus formulated concrete development directions, such as the principle and goal of focusing on fully mechanized mining determined by Lu'an, Jincheng, Yanzhou, Xingtai, Datong, Tiefa and other bureaus, the combined focus on fully mechanized mining and high levels determined by Xishan, Yangquan, Pingdingshan, Xuzhou, Jixi, Hegang, and other bureaus, and the focus on high-level common extraction determined by Qitaihe, Fengfeng, Huaibei, Fenxi, Xinwen, Feicheng, and other bureaus. Correct guiding principles and clear plan goals have effectively promoted development of mechanized coal mining.

7. They have integrated scientific research, manufacturing, and production for closer cooperation and joint attacks on key problems, which has accelerated the shift to domestic production of fully mechanized mining and fully mechanized excavation equipment. The coal system now has the capability of manufacturing 80 sets of fully mechanized mining and 210 sets of fully mechanized tunneling equipment each year. There are many good examples and much experience has been accumulated in the area of integrating scientific research, manufacturing, and production to attack key technical problems. An example is the obvious achievements made through S&T cooperation by Yanzhou Mining Bureau with the Coal Science Research Academy and by Jincheng Mining Bureau with several coal machinery manufacturing plants.

8. They adhered to the principle of a combined focus on excavation and haulage to achieve systematically matching and coordinated development. Many mining bureaus have adhered to the principle of synchronous development of mechanized coal mining and mechanized tunneling and made great efforts to increase the extent of fully mechanized tunneling to enable matching up with the fully mechanized mining capacity. Mine haulage to serve excavation has increased the pace of technical equipment modernization.

B. Resolute Technical Transformation in Mines, Actively Adopt Advanced Technologies and Equipment

Rich experience in the area of technical transformation in mines has been accumulated over the past 10-plus years:

1. There has been a focus on adopting advanced technologies and equipment to gradually shift mine production onto a new technical foundation. Since 1986, on the basis of the requirements of modernized mine construction, all mine transformation and expansion have consistently been done according to the standards of modernized mines with a focus on outfitting them with mechanized excavation and haulage. Fully mechanized mining, mechanized tunneling, and rock work lines have been installed for transformed and new mining regions and for work faces which have suitable conditions.

2. Mine opening deployments and tunnel deployments have been improved for rational centralization of production to create the conditions for developing mechanized excavation. The focus is on rational centralization of producing mines and widespread increases in the geometric dimensions of faces, mining regions, and levels. Technical transformation was used in mines with

several inclined shafts built together and inclined shafts that were opened up in groups to connect them together in deeper areas. At Jixi, Shuangyashan, Qitaihe, Huainan, Fengfeng, and other mining regions, technical transformation was used at 94 mines with small inclined shafts and dense concentrations of shaft entrances to connect them together into 31 large key mines. The average length of working faces in China's unified distribution coal mines was increased from 87 meters in 1978 to 101 meters. The strike distance in mining areas has been universally increased from the 500 to 800 meters of the past to 1,000 to 1,500 meters (single-flank mining areas) and 2,000 to 2,500 meters (dual-flank mining areas). The average step height has been increased from less than 100 meters in the past to 200 meters, and to 300 to 350 meters in mines which are extracting upward and downward in mountains.

3. Weak links in mines have been transformed to increase overall mine production capacity. Since 1976, technical transformation in mines has been used to transform hoisting systems in 270 mines by adopting larger units or replacement with lighter hoist containers and replacing or transforming hoisting equipment. Transformations have been carried out in mine haulage systems at 264 mines and most of the mines have switched to 3 ton and larger hopper cars or bottom and side-dumping mine cars, which has simplified the deployment of floor car parks. Mines with suitable conditions have changed from mine cart haulage to conveyor transport. Corresponding technical transformations have also been carried out in ventilation systems, drainage systems, ground coal dressing systems, car loading warehouses, coal storage yards, car loading stations and lines, and other production systems as well as in power supply, water supply, heat supply, pressurization, gangue removal, and other auxiliary production systems.

C. Adhering to Increasing Unit Output, Unit Driving Footage, and Efficiency as the Primary Direction of Attack and Achieving the "Three Increases" Is the Primary Measure for Comprehensive Improvements in Production Technology Levels

Achieving the "three increases" is the primary direction of attack to exploit potential in mines and an inevitable result of S&T progress in coal mining. The core of the "three increases" is increasing unit output from coal working faces. China's unified distribution coal mines have done a great deal of work over the past 10-plus years in the area of a focused attack on the "three increases" and they have derived prominent achievements and experiences.

1. They have widely and deeply undertaken competitive activities for excavation teams to break records, create levels, and raise targets. In 1981 the Yongdingzhuang No 4 fully mechanized mining team and Tongjialiang No 1 fully mechanized mining teams in Datong Bureau broke through the major barrier of 1 million tons of yearly output for the first time. After creating experiences as 1 million ton high output fully mechanized mining teams, under concrete organization by the Ministry of Coal Industry and all provincial bureaus and mining bureaus, 85 teams in 38 fully mechanized mining teams in 12 mining bureaus and 27 mines including Datong, Kailuan, Xishan, Lu'an, Pingdingshan, Yanzhou, Jincheng, Hegang, Yima, Jixi, Xingtai, Zaozhuang, and others achieved yearly output of more than 1 million tons from 1981 to 1988. Wangzhuang Mine No 1 fully mechanized mining team at Lu'an and Gushuyuan No 1 fully mechanized mining team at Jincheng made good yearly output achievements of 1.7 million tons and 1.8 million tons in 1987 and 1988.

There were six high-level common extraction teams with yearly output of 400,000 tons in 1985, seven in 1986, 11 in 1987, and 10 in 1988. High-level common extraction teams at Wannian Mine, Yangquhe Mine, and Sunzhuang Mine at Fengfeng, Gaoyang Mine at Fenxi, Nanshan Mine at Hegang, and Wangshi'ao Mine at Tongchuan create advanced levels in China.

There have been substantial developments in tunneling teams in raising target and creating level activities. In 1985 there were two teams which tunneled 10,000 meters in 1 year, and there was one in 1986, three in 1987, and six in 1988. There have been increases every year in the number of excavation teams which have raised targets in China's unified distribution coal mines. There was an increase of 224 coal mining teams which raised targets from 1985 to 1988 and an increase of 52 tunneling teams which raised targets.

2. Rational reductions in work faces and centralization of production are the key to increasing unit output and important indicators that coal production is moving toward the new route of internal expanded reproduction. This is especially apparent in Lu'an, Jincheng, Yanzhou, Xingtai, Fengfeng, Datong, Pingdingshan, and other bureaus. In 1984, Lu'an Mining Bureau produced 6.05 million tons from an average of 16.07 coal mining faces for a unit output of 28,197 tons/month and a stope productivity of 13.26 tons/manshift. Their output in 1988 was 10 million tons from an average of 8.92 coal mining faces for a unit output of 85,862 tons/month and a stope productivity of 44 tons/manshift. In 1984 Jincheng Mining Bureau produced 5.34 million tons from an average of 21.6 coal mining faces for a unit output of 18,120 tons/month and a stope productivity of 10.79 tons/manshift. Their output in 1988 was 10.03 million tons from an average of 10.14 coal mining faces for a unit output of 72,224 tons/month and a stope productivity of 44 tons/manshift. These changes in production technology indices at Lu'an and Jincheng Mining Bureaus are representative of the direction of developments in unified distribution coal mines throughout China.

In the area of increasing efficiency, increases in full-staff productivity first of all require increases in excavation productivity. Rely on advanced technical equipment and rational labor organization, and rely on increases in unit

output and unit driving footage, not on increasing the size of staffs. Many bureaus and mines have mature experiences in this area.

D. Resolutely and Continually Adopting New Technologies, New Equipment, New Techniques, and New Materials Are Important Aspects of Relying on S&T Progress in Coal Production

1. Reform and extend coal mining technologies and techniques. For the past several years, in rather difficult financial circumstances for the state, many bureaus and mines have used state-subsidized loans, raised their own capital, and used other methods to actively develop mechanized excavation and reform support of coal mining faces. Besides the extension of coal mining technologies described above, we also have integrated with national conditions to extend the utilization of single-unit hydraulic supports and improve the roof management situation. The number of single-unit hydraulic support work faces increased from 170 in 1985 to 619. On this foundation, we also developed interchangeable single-unit hydraulic supports suitable for use on blast extraction work faces and expanded the scope of utilization to use single-unit hydraulic supports on nearly 300 blast extraction faces and make considerable improvements in roof supports.

2. Innovation and extension of opening and tunneling construction techniques and technologies. The most prominent is extension of new smooth blasting shotcreting technologies. The dimensions of smooth blasting shotcreting driving footage in China's unified distribution coal mines in 1988 reached 1.282 million meters and its application has been expanded from mine floor cart lots, primary hauling tunnels, and rock doors to preparation tunnels and stope tunnels. The types of roof bolts have developed from wooden roof bolts and steel cable roof bolts to pipe-seam roof bolts and expanding roof bolts. Roof bolt fixing agents have developed from lateral-etching type to resin roof bolt fixing agents and rapid self-infusing cement roof bolt fixing agents, and shotcrete machines have developed from dry spraying to wet spraying, which has improved the quality of supports. At the same time, new types of support materials have developed rapidly, such as I-beam steel trapezoidal scaffolds, U-shaped steel retractable supports, trapezoidal retractable supports, and they have formed standard series. Metallic net backplates are being extended and utilized and they have played a major role in preventing leak-assisted hollow roofs and scaffold collapses.

3. New technologies, new techniques, and new materials for electromechanical haulage have been extended and applied. There have been substantial developments in the area of S&T progress with coal mine electromechanical systems over the past 10 years, definite achievements in replacement and transformation of outdated and complicated equipment, and considerable improvements in the technical characteristics of mine equipment which have played a role in promoting guarantees of safe production and improved economic results. In the area of hoisting systems, we have transformed old hoists, applied microcomputer technologies, and outfitted advanced comprehensive protection and extended spring valve monitoring equipment and braking equipment. Lightweight skips have been successfully developed as well as extended and utilized, which expanded hoisting capacity and aided safe production. In the area of power supply systems, we have extended and applied new technologies of the 1980's such as high and low vacuum switches, fire damping and shielded cables, various types of electronic protection equipment, conveyor protection equipment, and fire-resistant conveyor belts. Planned replacement and transformation have been carried out for low efficiency high energy consuming outdated and complicated ventilators and water pumps. Relatively rapid progress has also been made in attacks on key technical problems with mine haulage and in the extension and utilization of new technologies and new equipment.

E. Adhering to Scientific Management, Promoting Development of Coal Production

China's unified distribution coal mines have done a great deal of work in reinforcing enterprise management over the past several years. The most prominent thing is a focus on the three major matters, undertaking quality standardization, modernized mine construction, and enterprise upgrading activities, which have effectively promoted improvements in enterprise management levels. Many bureaus and mines have quite a few experiences and embodiments in this area. Practice has proven that administrative modernization is an important indicator of modernization in the coal industry and an important aspect of coal S&T progress. Advanced S&T are inseparable from scientific management. More advanced equipment, poor management, and inappropriate utilization will prevent their full conversion into forces of production and they will be unable to foster the appropriate benefits. Resolute adoption of advanced technologies and equipment and scientific management can effectively promote S&T progress and development of production in coal mines. For this reason, we must resolutely and unwaveringly push forward.

III. Prospects for Relying on S&T Progress To Develop Coal Production

Unified distribution coal mines will achieve raw coal production and safety indices for the Seventh 5-Year Plan ahead of schedule in 1989. In the future, we should continue to rely on S&T progress to develop coal production and we must truly make S&T a direct driving force for developing coal production. The focus of applying and extending successful experiences is developing mechanized excavation. The route to using technical transformation in mines to increase overall production capacity and economic benefits in coal mines and achieve coal mine modernization is:

1. Major efforts to develop mechanized excavation and comprehensive technical transformation in mines. Rationally centralize production, achieve the four centralizations for mines, levels, mining regions, and work faces, reduce the number of excavation faces, and increase output while reducing personnel to achieve increased unit output, efficiency, and capital recovery rates, simplify haulage systems, and apply continuous haulage equipment to increase economic benefits and the results of safe production.

2. Adhere to the development direction of fully mechanized mining and mechanized tunneling, actively create the conditions to extend the range of using fully mechanized mining and mechanized tunneling, and increase the proportion of output and driving footage for fully mechanized mining and mechanized tunneling. High-level common extraction should be popularized on work faces which lack the geological conditions for fully mechanized mining. We also should actively develop various mechanized extraction methods for special coal seam endowment conditions, develop hydraulic extraction where conditions are suitable for hydraulic mining, and gradually reduce the proportion of blast mining.

3. Where geological conditions permit, all newly built and expanded large and medium-sized mines should arrange for fully mechanized mining and mechanized tunneling equipment in mine designs or transformation and expansion designs according to modernized mining standards.

4. Technical equipment should basically come from domestic sources to gradually achieve domestic production of fully mechanized mining, mechanized tunneling, and other equipment.

5. Development of extraction, tunneling, and haulage should be synchronized. Actively improve and accelerate the development of new high efficiency and high power excavation machinery and matching electromechanical equipment.

Plans call for China's raw coal output to reach 1.4 billion tons by the year 2000, including 700 million tons from unified distribution coal mines. The degree of mechanization in coal mining in China's unified distribution coal mines should reach 76 percent, including 42 percent for fully mechanized mining and 34 percent for high-level extraction, and the degree of mechanization in tunneling and loading should reach 76 percent, including 22 percent for mechanized tunneling. To achieve this goal, the extent of mechanization in coal mining in China's unified distribution coal mines should reach 66 percent during the Eighth 5-Year Plan, including 36 percent for fully mechanized mining and 30 percent for high-level extraction, and the degree of mechanization in tunneling and loading should reach 66 percent, including 15 percent for mechanized tunneling.

Based on practice in coal production and construction and requirements in development plans for the Eighth 5-Year Plan, the main questions which should be reinforced and solved in the area of technical transformation in mines and mechanized excavation during the Eighth 5-Year Plan are:

a. In the area of technical transformation in mines: 1) Technical transformation in mines to use fewer investments to obtain more output and see results more quickly is a principle that should be adhered to for the long term. 2) Technical transformation in mines should be carried out on the basis of overall plans for mining regions with differential treatment and guidance by categories. Focused technical transformation in mines with rich reserves, good extraction condition, superior goal geology, and good haulage conditions can increase output substantially. To stabilize mine production levels, increase economic benefits, and improve safe production conditions in mines with substantial reserves, we should carry out regular technical transformation. In mines with small reserves, we should use technical transformation to actively search for coal and extend the period of stable output and shorten the period of reduced output. 3) We should use technical transformation in key mines to establish modernized mines. Technical transformation in key mines should be done in conjunction with expansion or moving deeper, and actively adopting new equipment, new technologies, new techniques, and new materials to raise technical levels one step higher.

b. In the area of mechanization of excavation: 1) In conjunction with major efforts to develop and utilize fully mechanized mining on gently sloping coal seams of medium thickness, we should further improve equipment standardization and systemization. The focus at the present time should be on developing the adaptability of thick coal seam caving fully mechanized mining equipment and solve problems with increasing resource recovery rates and fire extinguishing. The focus in technical research undertaken on developing mechanized extraction of thin coal seams is on developing coal cutters and fighting to make breakthroughs in equipment and technologies. Do research on technologies for mining coal in steeply inclined coal seams and change the backward situation in mechanization in this area. Do research on mechanized excavation coal mining equipment for use in hard-to-mine coal seams with special geological conditions, such as coal mining equipment and technologies under "three softs" and "three hards" conditions. Reinforce attacks on key problems with components and increase equipment reliability and adaptability, such as attacks on key technical problems to increase the lifespan of hydraulic supports and 1,000-jin roof sealers, the firmness of electroplated layers and the fatigue strength of soft pipes, safety valves, initial supporting force guarantee valves and hydraulic pumps, hydraulic motors, and so on. 2) Actively extend metallization of tunneling tunnels. Extend them for 10 million meters in the Eighth 5-Year Plan for 2 million meters each year. We also should gradually enlarge the cross-section of tunnels. The small cross-sections of tunnels in

a few large mines and in many producing mines over many years are not adapted to the requirements of developing production. The goal in doing this is to make basic changes in the support situation in tunnels. 3) Increase the lifespan of central troughs in scraper conveyors and strive to attain a coal handling capacity of 2.5 million tons. Actively adopt track cars (and gear cars), single-track cranes, and other new haulage arrangements and solve problems in difficult haulage in large, long, steep, and gentle tunnels.

One extremely serious problem in developing mechanized coal production at present is a tendency toward aging of fully mechanized mining equipment which enterprises are unable to replace. This will greatly affect development of S&T progress in coal mines. Recently, the China Unified Distribution Coal Mine Corporation submitted a report to the State Council concerning a request for solutions to the question of replacing fully mechanized mining and mechanized tunneling equipment in an effort to solve it by adopting the method of state financial subsidies and increased maintenance expenditures and in conjunction with raising capital through many areas and many channels to develop mechanized excavation. Channels also should be opened to implement projects and capital for technical transformation, projects and capital to prevent water, capital and policy measures for replacing and transforming old equipment, and so on.

There is now a definite foundation for S&T progress in China's unified distribution coal mines and the achievements are obvious. Although many difficulties and problems persist, if we conscientiously adhere to the principle of relying on S&T progress, continually raise technical levels and equipment levels, strive to reinforce basic work in enterprise management, improve the technical qualities of employees, and promote modernized mine construction, we certainly will be able to achieve the goal of developing coal production.

Accelerating Mine Construction by Relying on Scientific, Technological Progress

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[Article by Shen Dechen [3088 1795 3819], director of the China Unified Distribution Coal Mine Corporation Capital Construction Bureau and professor-level senior engineer: "Rely on Scientific and Technical Progress To Accelerate Coal Mine Construction"]

[Text]

I. An Overview of Coal Mine Capital Construction

China's coal industry has developed quickly in the 40 years since the nation was founded, with coal output rising from 30.34 million tons shortly after liberation to 1 billion tons in 1989. Capital construction for coal played an important role in this. In the past 40 years, we started construction of 2,239 new mines (including strip mines) with a capacity of 691.68 million tons. We have completed 2,157 mines (including strip mines) with a capacity of 587.14 million tons. We have 163 coal dressing plants with a washing intake capacity of 180 million tons and we have built 4,920 kilometers of dedicated rail lines in mining regions and built several matching coal projects associated with them. This is especially true for 1988, when the additional production capacity placed into operation at mines that directly supply central authorities broke the 30 million ton barrier for the first time. There has been a substantial increase in the pace of construction in recent years and obvious reductions in construction schedules. The construction schedule for mines from 1979 to 1980 was 98.5 months. The average construction schedule during the Sixth 5-Year Plan was 83 months, and the average construction schedule during the first 4 years of the Seventh 5-Year Plan was 70 months. The construction schedule for the 3 million ton Yanzhou Xinglongzhuang Mine completed and placed into operation in 1986 was 82 months. The construction schedule for the 3 million ton Gujiao Xiqu Mine completed and placed into operation in 1984 was 64 months, and it is expected to take 5 years to complete the 4 million ton Gujiao Dongqu Mine. There have been fundamental changes in the technical situation in mines placed into operation during the Seventh 5-Year Plan. We completed the Haizi, Xin'an, Wangcun, Zhenchengdi, Wangping, Baodian, Xiqun, Yanzishan, Tiejiaying, and several other large and extra-large modernized mines. These mines have perfect safety monitoring, monitoring and control, and communications equipment.

Over the past 40 years, we gradually established a specialized capital construction staff which understands advanced technology and modern construction equipment. At the end of 1989, China's coal capital construction staff totaled 390,000 which formed 210 engineering offices including mine construction, civil engineering, installation, special drilling, highway construction, and so on. They have 110,000 pieces of construction equipment of various types and power equipment with a total power of 2,000 MW. This specialized construction staff is qualified in mineshaft, cavern, and tunnel construction in all types of complex strata and geological conditions, all types of new structural tall structures and plant buildings, and installation of large-scale automated electromechanical equipment. It can take on construction of 200 million ton scale shaft mines (and strip mines), coal dressing plants, and the corresponding matching projects. The construction staff has also begun to enter international markets. In 1988, in bidding by 13 companies in eight countries for Morocco's (Jiela) Mine, the Jiangsu Capital Construction Company won the bidding and assumed responsibility for the project. China now has 29 specialized coal mine design academies including 14 grade-A design academies and over 12,500 design personnel (at the end of 1989). This specialized design staff can use computers and other modern measures to design extra-large, large, medium-sized, and small shaft

mines and strip mines and coal dressing plants, and they can design coal machinery plants, power plants, coal gas plants, coal-water mixtures and pipelines, and other projects associated with mining regions.

II. Coal Capital Construction S&T and Production Achievements

Several scientific research projects in China's coal capital construction have been completed which have reinforced new equipment development, improved construction technologies, and undertaken soft science R&D for construction organization and management. During the Seventh 5-Year Plan, we have completed over 200 scientific research achievements and received 12 state S&T progress awards. They have played an active role in accelerating the pace of construction and increasing economic results.

1. Vertical shaft construction. The Ministry of Coal Industry, Ministry of Metallurgical Industry, and First Ministry of Machine Building have made several positive achievements in their efforts to use scientific research to attack key technical problems in mechanizing vertical shafts. They have formed mechanized work lines for large-scale shaft sinking drill stabilizers, hoists, new Model-IV and Model-V frames, umbrella frames, deep-hole smooth blasting, rock loaders, shotcreting sliding molding structure walls, and so on, and we have basically achieved mechanization of primary shaft sinking procedures. Huainan, Huaibei, Yanzhou, Tiefa, Handan, Pingdingshan, and other mining regions have now been outfitted with the equipment. Deep hole blasting in 3 to 4 meter vertical shafts is now being extended and utilized in over 20 shafts and the blasthole utilization rate has surpassed 85 percent. Several units are using this equipment and technology for rational improvement of techniques and labor organization, and they have achieved rather good results in shaft construction. Monthly shaft completion has surpassed 100 meters in nearly 30 instances. Fengfeng Jiulongkou South Ventilation Shaft, for example, was completed to depth at 523 meters in 11 months, an average monthly shaft completion rate of 61.5 meters and 104 meters in the highest month. Construction of the primary and auxiliary shafts at Xinwen Zhaizhen Mine was completed in the same year with an average monthly shaft completion rate of 46 meters. Average monthly shaft completion at Guwen Malan North No 2 Ventilation Intake Shaft was 54.8 meters. The average monthly shaft completion rate for Qitaihe Tiaoshan Vertical Ventilation Shaft was 51.5 meters. The highest monthly shaft completion rate at Huainan Xieqiao Gangue Shaft was 102.6 meters. The highest monthly shaft completion rate at Daxing Central Ventilation Shaft was 123 meters. The shaft was completed to depth in 5.5 months at an average monthly shaft completion rate of 89.01 meters. The average monthly shaft completion rate for all of China's vertical shafts was 13 percent higher than during the Sixth 5-Year Plan.

Vertical shaft mixed operation patterns have been widely utilized. The normal construction pace for shafts which use mixed operations is over 40 meters/month and construction costs are greatly reduced. At Huaibei Luling Shaft, for example, the monthly shaft completion rate was 46.43 meters and construction took 9 months, which was 6.7 months ahead of the contract. The entire shaft conserved 28 tons of steel, 208 cubic meters of timber, and reduced construction costs by 12.9 percent. The quality of the entire project met specifications and the superior quality product rate was 54.2 percent. Serious injuries and accidental deaths were completely eliminated during construction. The highest monthly progress at Jixi Xinghua Main Shaft was 92 meters, the average monthly progress was 50.3 meters, and the cost per meter was just 4,360 yuan.

Successful development of back-shaft drilling rigs achieved mechanized construction of in-shaft coal storage, smooth coal holes, and so on, accelerated the pace of construction, and improved construction safety conditions. Wennan Coal Mine used an LM-200 back-shaft drilling rig in 1989 to drill a smooth gangue hole 316 meters deep and 1.4 meters in diameter in 42 days. The net drilling rate was 1.01 meters/hour, the average monthly progression was 256 meters, and the deflection rate was 0.88 percent.

There have been developments in shaft corrosion prevention technologies and we have successfully developed many types of superior quality corrosion preventing coatings and corrosion preventing methods, as well as composite materials series shaft equipment. Corrosion prevention processing is now being carried out for most shaft equipment in vertical shafts being built in China and their useful life can be more than doubled.

Resin roof bolt shaft fixing equipment and technologies are now being extended and applied in 104 shafts in China. They have accelerated the construction pace of shaft installation, guaranteed the quality of shaft walls, and reduced the cost of project construction. They are very important for reforming equipment structures and techniques in large shafts and deep shafts, and they facilitate future maintenance and replacement of shaft equipment.

2. Special shaft drilling. Rather complex engineering geology and hydrogeological conditions have been encountered during new shaft construction in many mining regions. The result has been a gradual increase in the proportion of special construction. Statistics indicate that freeze method construction has been used in nearly 300 shafts and the total depth of freezing is nearly 50 kilometers. The maximum freezing depth is 415 meters and the thickest Quaternary alluvial strata drilled through has been 358.5 meters. The freeze method has now become the primary method for moving through complex unstable alluvial strata and water-bearing fissured strata in China. Freeze method shaft sinking technologies have now developed to a new level. We have developed a high efficiency special purpose drill rig

for boring frozen holes, gyro gradiometers which do not use drill rod lifting gradiometers, and high freezing efficiency movable threaded rod freezing machines. We have experimented with and extended differential freezing, local freezing, scheduled freezing, dual liquid supply pipe freezing, guide track freezing, dual hole freezing with additional auxiliary holes, and other freezing methods. We have extended dual-layer concrete shaft walls, plastic laminated shaft wall structures, and hydraulic sliding molding structure wall techniques. The use of drilling and blasting method tunneling technologies and temporary net shotcrete support technologies, and so on have been adopted for bedrock freezing sections.

Grouting method construction has been adopted for over 120 shafts, including ground surface pregrouting on 60 at a maximum depth of 665 meters, and good achievements have been made in extending and applying direct leak blocking technologies in several mines. The water flow after completion in most shafts which were grouted was less than 10 cubic meters/hour. We have now developed grouting materials with various properties, special drill rigs for drilling grouting holes, grouting pumps, and grout stopping plugs.

We have built 40 shafts using the shaft drilling method and the total depth of shaft completion is 8,600 meters, the maximum shaft drilling diameter is 9.3 meters, the maximum shaft drilling depth is 508.2 meters, and the high monthly shaft completion rate was 74.73 meters. The strata drilled include quicksand, clay, gravel, weathered zones, and even hard rock. China has successfully developed a new generation of 9 meter diameter shaft drilling rigs and knives which have also reached levels of similar products in foreign countries. Mud wall protection and processing technologies can now basically guarantee the safety of shafts that are drilled and effectively control contamination of industrial sites by mud. Successful development of ultrasound loggers has basically solved the problem of measuring the verticality of shafts and the shaft completion deflection rate can be held to within 0.08 percent. Successful development of high strength steel rod reinforced concrete shaft walls and steel plate composite shaft wall structures have become an effective construction method in opening passages in 400 meter and thicker Quaternary alluvial strata in China.

There are 156 shafts which have been constructed using the sunk shaft method with a diameter that is usually 4 to 6 meters, a sinking depth generally within 100 meters, and a deflection rate that is generally less than 1 percent. This is especially true for Qufu Danjiacun Mine, which used underwater broken earth, pressurized air slag removal, mud wall protection, active deflection correction, and other unusual technologies to create a national sinking record of 192.78 meters (the world record is 200.3 meters).

We have built 24 shafts using the screen method. The shaft diameters are generally 4.5 to 6 meters and the maximum is 8 meters, the depths are generally 30 to 40 meters and the maximum is 57 meters. After several years of exploration, and especially through practice at Longkou Liangjia Mine and Beizao Mine, we have basically formed a set of rather effective construction technologies which form troughs and make holes by "first guiding and then expanding, using two drills and one splitter" and preparing steel pipe connector holes.

3. Tunneling rock tunnels. There have been developments in mechanized rock tunneling. Scraper head rock loading series have become the primary rock loading machinery in rock tunnel tunneling. For the past 10-plus years, we have produced scraper head rock loaders with adjustable car plates, crab-claw rock loaders, drill loaders, side-dumping rock loaders, high capacity rear-dumping rock loaders, conveyor transfer carrier series, shuttle carts, single track cranes, and other tunneling machinery which have raised levels of mechanization in tunnel tunneling, the rate of tunneling, and efficiency. Over the past few years we have begun outfitting several mechanized work lines, mainly with hydraulic hoists, side-dumping rock loaders, and conveyor transfer carriers. Their monthly driving footage is generally 100 to 200 meters and the maximum is 252.4 meters. In addition, we have also focused on developing full cross-section rock tunnel tunnelers. The first 3 meter diameter tunneler completed three rock tunnels a total of 3,000 meters long and a 5 meter diameter tunneler has tunneled a 3,000 meter flat cavern at Gujiao Dongqu with a maximum monthly driving footage of 202 meters, a maximum daily driving footage of 12.7 meters, and a maximum shift driving footage of 5.8 meters. The quality of the completed tunnel project met specifications and the superior quality product rate was 56 percent. A 3.2 meter diameter tunneler has tunneled over 1,000 meters of tunnels at Yangchang Coal Mine with an average monthly driving footage of 156 meters, a maximum monthly driving footage of 260.17 meters, and a maximum daily driving footage of 13.6 meters. Another 3.2 meter full cross-section tunneler has also been placed into use at Lindong Coal Mine.

There have also been breakthroughs in support technologies. Since we began extending shotcrete supports in the 1970's, shotcreting technologies are being used entirely in over 90 percent of our rock tunnels at present. Shotcrete supports are also used in many coal tunnels with very good technical and economic results. Neutral point theory and surrounding rock flexible ring theory have provided a scientific foundation for the development of shotcrete support technologies. Definite advances have also been made in the areas of lowering resilience and reducing dust. Net shotcreting, metallic fiber shotcrete support, hydraulic expanding roof bolts, pipe slit roof bolts, concrete roof bolts, and chemical rolls are now being extended and utilized.

Soft rock support is a big problem in coal mine rock tunneling. After doing research and experiments, we have proposed combined support using steel supports

and shotcrete, dual layer material rock arch sealed supports, combined shotcrete and net support, combined anchor rope, roof bolt, and shotcrete support, and so on. We are also actively developing curved-plate support technologies to provide a technical route for completely solving the problem of soft rock support.

4. Inclined shaft construction. We have formed mechanized construction technologies for smooth blasting, laser orientation, large scraper head rock loading, large skip hoisting, and large gangue hoppers for gangue storage which have provided a maximum monthly driving footage rate of 705.3 meters in construction of several inclined shafts in China. They were also used in construction of a main inclined shaft 1,000 meters long and 20 square meters in cross-section at Yangquan Guishigou Mine in 1986 which was drilled to depth in just 1 year.

5. Structure installation. We have carried out widespread wall reform, extended and applied hydraulic sliding molding, artificial foundation reinforcement, concrete pumping, compound steel templates, and other new technologies which have accelerated the pace of construction and conserved large amounts of timber. We have also extended and utilized water reducing agents and various other types of applied agents in large scale concrete engineering which saved large amounts of cement. We have carried out reforms in construction technologies for large structures like round storehouses at coal storage yards, shaft towers, large diameter round structures for coal dressing plant concentration pools, main plant buildings for coal dressing plants, and so on. There have also been major developments in mechanization of construction. While relying on Chinese-made equipment, we have also imported extracting, loading, hauling, lifting, and other advanced equipment from foreign countries. Excluding manual work lines for bricklaying, coating, and architectural engineering, mechanization and semi-mechanization have now been basically achieved for earthworks engineering, steel reinforced concrete operations, and horizontal and vertical haulage, which has pushed China's coal mine ground surface structure construction up to a new level. It deserves mention that we have also used the integral translation method to build two steel reinforced concrete shaft towers and one steel shaft tower. The main shaft at Huaibei Zhuxianzhuang Coal Mine has a steel reinforced concrete shaft tower weighing 6,800 tons and 62 meters tall that was completed in one try using the integral translation method.

6. Obvious advances in design technologies. We have actively extended a technical policy of one-time design, construction in stages, and operationalization in stages centered on adopting technologies and building modernized mines. We have also made substantial progress in transforming opening deployments, rational centralization of production, reducing the amount of engineering and ground structures, drilling more coal tunnels and fewer rock tunnels, producing coal more quickly, attaining full output, and other areas and attained new levels in mine design. In just 3 short years, there has been substantial growth in the development and utilization of computers. In our main design academies, computer plotting accounts for 20 percent of total plotting, computers are used to make 50 percent of total design calculations, and they account for 80 percent of the total number of design documents published. Coal mine design has moved to new levels. In the past 10 years, 14 mine and coal dressing plant designs have received state superior quality design awards, 15 have received provincial and ministry-level awards, and 200 single item designs have received provincial, municipal, ministry, and state single item awards. Nine pieces of computer software have received state gold medal and silver medals. Our designs have also moved into international markets. Gansu Coal Mine Design Academy and Guangdong Coal Mine Design Academy designed a hospital in Somalia and a coal dressing plant in Nepal. Wuhan Coal Mine Design Academy assumed contractual responsibility for designing a 300,000 ton mine in Indonesia.

7. Large strip mine equipment has gradually moved toward domestic production. We have already cooperated with foreign countries in producing 25 cubic meter single bucket electric shovels and we are now manufacturing 68 ton and 108 ton heavy dump trunks as well as 154 ton trucks on a trial basis. Domestic production of large strip mine equipment has received a first place state S&T award. We have also begun developing continuous mining technical equipment.

8. Continual improvements in construction management techniques. Systems engineering and network technologies are now being widely used in construction organization and design and we are using computers to do the computations. We have made obvious achievements in shortening construction schedules and conserving capital by using optimized construction programs and improving construction management. Network management and electronic computers were used for three vertical shafts at Yanzhou Yangcun Mine, and the CPM method was used to arrange for construction. All items of work were arranged, coordinated, and matched up well, which resulted in an obvious speeding up of the pace of production. The 330.8 meter deep main shaft and auxiliary shaft and 243.8 meter deep ventilation shaft were drilled to depth in 1 year. The average monthly driving footage on the auxiliary shaft was 44 meters and the average monthly driving footage on the ventilation shaft was 46.3 meters.

To continually improve enterprise quality and reinforce enterprise management levels, comprehensive quality management has been universally extended throughout China's coal capital construction system. Over the past several years, the construction industry has held seven comprehensive quality management study courses and trained a total of 650 key enterprise leadership and group cadres. Education in comprehensive quality management in primary design academies has reached 90 percent and several design academies have been inspected and met specifications. They will enter the advanced

ranks of comprehensive quality management in the national design system during 1990. The development of quality management group activities has laid a foundation for ministry-level superior quality projects and state-level superior quality projects. Datong Coal Dressing Plant received a state superior quality project gold medal in 1983 and Xinglongzhuang Coal Dressing Plant and Dongpang Coal Mine received state superior quality silver medals in 1988 as well as state construction industry "crash course" awards.

Quality supervision stations were established in 1987 and their number had grown to 129 by the end of 1989. We have established and maintained 43 inspection stations at all levels which have focused strictly on quality in construction and played a decisive role in improving project quality.

III. Conclusion

Coal is China's primary energy resource. Based on the needs of national economic development, raw coal output must reach 1.4 billion tons by the end of this century. Thus, besides transformation and expansion to increase output in existing producing mines, we also must continually expand the scale of new mine construction to be able to complete this task. Preliminary estimates indicate that we must guarantee that 30 to 35 million tons is placed into operation each year and that the mine construction schedule must be reduced to less than 6 years if we are to be able to meet basic demand. In a situation of large shafts, deep shafts, limited investments, and complex geological conditions, the basic way to complete this arduous task is extensive reform and reliance on S&T progress to push the pace of construction forward, raise the quality of projects, reduce construction schedules, and reduce project construction costs. These are the central tasks in future coal capital construction and scientific research. For this reason, we must strive to truly improve technologies, perfect equipment, develop new materials, reform techniques, optimize organization, achieve scientific management, conscientiously summarize and absorb advanced experiences and advanced equipment from foreign countries, and adhere to the principle of integrating the long term and short term, integrating applied technology with basic theoretical research, integrating scientific research to attack key problems with resolving real problems, integrating design, scientific research, and manufacturing and integrating exports from foreign countries with manufacturing within China to further improve technical levels and economic results for coal capital construction and make a contribution to the development of China's coal industry.

Coal Field Geological Exploration Reviewed

906B0075D Beijing SHIJIE MEITAN JISHU [WORLD COAL TECHNOLOGY] in Chinese No 4, Apr 90 pp 17-20

[Article by the China Coal Field Geology Bureau: "A Review of Geological Exploration in China's Coal Fields"]

[Text]

I

China's main energy resource is coal. Coal accounts for over 76 percent of our energy resource structure. We have extremely abundant coal resources, with projected coal resources of more than 4 trillion tons, and we have proven coal reserves of more than 800 billion tons. Our coal output surpassed the 1 billion ton benchmark in 1989.

There are 14 coal formation periods in China's geological history, the most important ones being the Carboniferous-Permian and Jurassic eras. The Carboniferous-Permian is mainly distributed in eastern China and was formed mostly in vast offshore or littoral environments. It accounts for about 30 percent of our resources. The Jurassic is distributed in northeastern and western China and was mainly formed in continental basins. It accounts for about 60 percent of our total resources.

The North China coal-bearing region located in east and central China is an enormous platform-type coal forming subsidence region. Its scope covers about 12 provinces and the coal-bearing area is about 800,000 square kilometers. Most of its coal was formed during the Carboniferous and Permian eras and the basement of the coal system is Cambrian and Ordovician limestone. Extractable coal seams are widely developed on peneplained sedimentary foundations and the primary coal seam positions gradually rise with regularity moving from north to south. In the Ordos platform-subsidence in the western part of the coal-bearing region, the Carboniferous and Permian coal fields are covered by rich coal-bearing Jurassic coal fields and they are structurally simple, have a gentle attitude and excellent coal quality, and contain unusually thick coal resources. It includes the region where Shanxi, Shaanxi, and Inner Mongolia join, which is China's primary coal industry base area during this century.

The late Jurassic was the primary period of coal formation in the northeast coal-bearing region located in northeast China, along with some from the early and middle Jurassic and Tertiary. It is composed of several 10 coal-bearing basins arranged in rows with a northeast or NNE strike. The coal system strata are thick and there are many coal-bearing strata. The total thickness of the extractable coal seams and the thickness of the single primary coal seams are both substantial, but there are rather abrupt variations in thickness. The western part of this coal-bearing region has many mining regions with gentle attitudes and enormously thick coal seams, and it is suited to open-cut mining.

Generally speaking, although coal resources are rather widely distributed in the south China region south of the Yangzi Jiang [Chang Jiang], they often cannot be important coal producing mining regions because of their complex structures and relatively thin coal seams. Resources are relatively concentrated in south Sichuan, west Guizhou, and east Yunnan and the coal was mostly

formed during the late Permian. This area's resources account for about 75 percent of the total for the 12 provinces of south China and they are mined in large numbers of medium-sized and small coal mines.

Strictly in terms of the amount of reserves, China's richest area in coal resources is located in Xinjiang in the vast northwest. Coal producing areas of Xinjiang are located mainly to the north and south of the Tian Shan range, mainly in the northern frontier. The coal formation period was the early and middle Jurassic and it formed in a region of sustained subsidence in the premontaine subsidence zone after Hercynian folding. They are formed of several large coal basins, the most important of them being the Junggar Basin, Turpan Basin, Yining Basin, and others. Most of them contain many coal-bearing strata and the coal seams are very thick. Moreover, they often contain large mining regions with enormously thick coal seams and extremely rich reserves. At present, proven reserves in this region account for a miniscule proportion of China's total resources and very little coal is being mined there. This is a region with enormous potential for developing China's coal industry in the future.

China has a full complement of coal varieties that are divided into 14 categories ranging from lignite to anthracite according to state standards. Coal used for coking is widely distributed and comes in a full complement of varieties. It accounts for over 30 percent of our total proven reserves and mostly has a moderate to rich ash content, moderate to rich sulfur content, and mid-range dressability. It is used mainly as a mixing coal for coking. The quality of non-coking bituminous coal is universally better than coking coal. The main producing regions are Shanxi, Inner Mongolia, and the northern part of the Ordos Basin. It accounts for over 30 percent of our total proven reserves and most has a low ash and low sulfur content. The heat output is over 30 MJ/kg and is mainly power coal used to generate electricity, and so on. Most of our anthracite has a moderate ash content, and part of it has a low and extra-low ash content. The key producing regions are in north, south-central, and southwest China, and it accounts for about 20 percent of our total proven reserves. It is used mainly for power and smelting. Our lignite is mainly distributed in northeast China, Inner Mongolia, and Yunnan, and accounts for over 10 percent of our total proven reserves. Most of it is of medium quality with a heat output of about 25 MJ/kg. Most of it is now being used in powdered coal boilers to generate power.

In summary, China has many coal formation periods, wide distributions, rich resources, and a full complement of coal varieties. Regions with rich concentrations of coal resources are unevenly distributed, however. In terms of latitude, they are mainly concentrated north of the Kunlun Shan range and Qinling Shan range. In longitude terms, they are mainly distributed to the west of a line running from Daxing'anling, Taixing Shan, and Xuefeng Shan. The richest provinces are Xinjiang, Inner Mongolia, Shanxi, and Shaanxi. In summary, China's coal resources are concentrated in the central and western parts of north China. This objective resource distribution configuration determines that China will face a long-term situation of shipping coal from north to south China and from west to east China.

II

Coal field geological survey work in China began in the 1920's but large-scale coal field geological exploration and coal field geological research has only been done in the 40 years since new China was established. Coal output in China has grown from 32.34 million tons in 1949 to 1 billion tons in 1989, a more than 30-fold increase over 40 years.

Coal field geology work in China has always been focused on the needs of coal mine construction, pressing forward quickly with the things it needs and moving first on the best. This has been the guiding ideology in our work and we have always implemented it conscientiously over the past 40 years. Coal mine construction shortly after the nation was founded mainly involved restoration and rebuilding of devastated old mines and coal field geology also began the corresponding work based on this need. After 1956, as large-scale economic construction by the state got under way, coal field geological workers summarized exploration experiences in old mining regions and applied the electrical method, gravitational-magnetic, exploratory drilling, and other methods on the basis of analyzing the relationships of strata sequences and structures to actively search for new coal fields in concealed and semi-concealed regions. Major breakthroughs and substantial achievements in this work were made in particular in the eastern part of the north China coal-bearing region. This guaranteed that construction of a large group of new mining regions and new mines would push China's coal industry into a new stage of development. In the late 1950's, we organized coal field forecasting work throughout China and achieved greater systemization and theory formulation for the work described above. We also expanded on it in other regions of China in adaptation to local conditions, which promoted a high tide of discovering new coal fields and guaranteed the needs for burgeoning development of the coal mine construction industry. After entering the 1980's, China initiated a new period of reform and opening up and there was even greater development of coal as our primary energy resource. There were also continual improvements in coal mine excavation technologies. To adapt to the demands of this new situation, coal field geology work continued to expand resources and worked everywhere to find new coal fields, and it made new explorations in the areas of improving the precision of exploration and shortening exploration schedules. At the same time, to adapt to the needs of large strip mine extraction and opening up old mines to greater depths, we also carried out the corresponding geological exploration work.

As everyone knows, the economically developed regions of China are mainly concentrated along our east coast.

The areas where the coal industry has developed fastest and where the strength of development is greatest also are concentrated in east China. After several new coal fields were discovered and large coal mines were built in east China in the 1950's and 1960's, the extent of coal resource utilization in this region was already very high. There were fewer and fewer regions which could be used for new mine construction and it became increasingly difficult to find new coal fields. This was an obvious contradiction in the development of China's coal industry. In the long term perspective, we naturally should actively develop the coal industry of central and west China to gradually alleviate the supply and demand configuration in which coal is shipped from west to east China. At the same time, however, coal field geology workers also continued to apply new theories and new technologies in east China to open up new realms in the search for coal, and they have made gratifying achievements. First, on the basis of new principles in geodynamics and other areas, they focused on studying gently inclined fracture structures in coal fields. In the famous Huainan Basin in Anhui, several billion tons in new coal resources were found beneath nappe structures. Research on gravitational gliding structures on the southern flank of Song Shan in Henan led to the discovery of several 100 million tons of coal reserves which can be utilized in the short term. In Fujian Province along China's southeast coast, there are often alternating nappe and decollement structures in many coal fields. After careful study of these structures, new resources have been reassessed. Second, geophysical exploration is playing an increasingly important role in eastern China, which is capped by Cenozoic strata over a large area. Discovery and confirmation of many new coal fields in the late 1950's were inseparably related to electrical method and gravitational-magnetic work. Seismic exploration methods have been widely used in coal field exploration since the 1970's. Along with continual discoveries and proving in several important coal mine regions of southwest Shandong Province and continual expansion of achievements in finding coal on the plains in southern Tianjin and in the region where Jiangsu, Anhui, and Henan join, the role of geophysical exploration is becoming increasingly important in the coal field geological exploration process and the methods are becoming increasingly mature. It has become an indispensable measure for locating coal beneath capping strata and it has played a unique role in increasing the precision of exploration and shortening exploration schedules. Comprehensive exploration methods which integrated high resolution seismic exploration, geophysical well logging, and exploratory drilling in several mining regions in Anhui and Shandong in recent years have conserved exploration expenditures and accelerated the pace of exploration, and they have doubled the precision in controlling faults and folds compared to the usual exploration methods. They can determine faults with a displacement of 15 meters in first-level first period mining regions, and they can even determine faults with a displacement of about 10 meters in work in certain producing mines. These achievements undoubtedly can provide an important foundation for mechanized excavation in coal mines.

Based on China's experiences in developing its coal industry over several decades, coal field geological exploration generally must lead coal mine construction by 5 to 10 years to enable rational planning and resource development. Coal field geological exploration work has been reinforced in the central part of central China since the 1980's. Several extra-large mining regions with reserves of several 10 billion tons and even 100 billion tons have been discovered in recent years at the junction of the borders of Shanxi, northern Shaanxi, and western Inner Mongolia. The area of Shenmu and Fugu in Shaanxi and Dong Sheng in Inner Mongolia alone has proven Jurassic coal reserves of more than 200 billion tons, and most of it is low-sulfur, low-ash superior quality power coal. This zone of rich coal resources will be developed as an important coal industry base area and has laid a necessary foundation for a strategic shift westward in the focus of coal mine construction.

Because of the close relationship between coal mine development and water resources, China often combines coal field exploration work with synchronized or matching geological work concerning water resources in mining regions. For the past several decades, water resource surveys have basically been able to meet the requirements of coal mine construction. During the process of developing coal fields in central and west China in the future, work in this area may become more difficult and more important.

During the process of serving coal mine construction, coal field geological work also has carried out the corresponding exploration in stages. The scope of work has moved from coal fields to mining regions and then to mines, the extent of work has moved from the overall to the precise, and the density of engineering has moved from the scattered to the concentrated. It is carried out gradually in sequence with a clear division of levels according to the different procedures of coal mine construction. Practice over 40 years has proven that this method of working in stages conforms to the objective laws of material understanding of mankind. It helps rational development of coal resources and it can avoid mistakes in work. Moreover, to guarantee the reliability of geological data, China's coal field geological exploration work has placed special emphasis on the importance of quality and it has formulated a set of quality standards and the corresponding project inspection and acceptance methods. In exploratory drilling, geophysical logging, geophysical prospecting, topographic and engineering surveys, water sampling experiments, sampling and chemical testing, and other areas, we have a set of relatively mature quality management measures to guarantee the reliability and accuracy of coal field geological data.

Coal field geological work is a science with very strong exploratory, scientific, and regularity properties. For this

reason, along with guaranteeing the needs of coal mine construction, coal field geological work also should promote its own development as well as form and establish China's coal field geology. This includes research on coal-bearing strata in China, research on regional structures in coal fields, small structures in mines, and special forms of coal seam structures, research on coal-bearing formations, sedimentary environments, and lithofacies paleogeography, research on coal metamorphism factors and coal metamorphism laws in China, and so on. Moreover, the major accomplishments were collected and published in two national coal field forecasts and two editions of ZHONGGUO MEITIAN DIZHIXUE [CHINESE COAL FIELD GEOLOGY]. The first national coal field forecast completed in 1959 promoted the first successful high tide of new coal field discoveries and they were given theoretical conclusions and descriptions in the edition of ZHONGGUO MEITIAN DIZHIXUE published in 1961. The second coal field forecast and new edition of ZHONGGUO MEITIAN DIZHIXUE were undertaken simultaneously and were completed during the period from 1979 to 1981. This achievement was also adapted to the stage of great difficulty in locating coal and the need to develop toward greater precision in coal field exploration work. China has a vast territory and huge population and many coal formation periods. Coal fields from different periods and in different regions have their own particular formational and evolutionary characteristics, and this is of great practical significance and theoretical value, and it is a quite attractive field of study with great potential.

China's coal field geological exploration work has developed for 40 years and it now has a staff of 100,000. China has 123 coal field geological exploration teams of various types scattered throughout the country which include specializations like aerial surveying, remote sensing, gravitation, magnetic method, electrical method, seismological, coal field surveying, coal field prospecting, hydrogeology, engineering geology, and so on as well as scientific research, computing centers, chemical experiment and testing, plotting and printing, machinery development and repair, and other comprehensive geological exploration forces with many job types, many measures, and many functions. They have become an indispensable army for guaranteeing coal mine construction and promoting development of the coal industry and they will continue to make new contributions in future work.

III

As China's coal industry enters the 1990's and struggles toward the goal of yearly coal output of 1.4 billion tons in the year 2000, coal field geological work will also make new efforts in this regard. The main goals of work over the next 10 years will include six areas:

1. Continuing to search for new coal resources and accelerating the pace of exploration in the industrially developed regions of east China will still be an urgent task of coal field geological work. The strength of development in east China is great, the extent of geological work is high, and there is a large region capped by the Cenozoic, so there may be few opportunities to find new resources. Moreover, they are generally deeply buried. All these things require coal field geological workers to redouble their efforts and take full advantage of the role of science and technology if they are to achieve the expected results. At the same time, coal field geological work in central and western China should be gradually reinforced, especially in central China, and should be integrated with groundwater resource surveys to accelerate the pace of coal field geological exploration. In areas where conditions permit, we will also adopt integrated geological and geophysical methods. In summary, the principle for deploying exploration is reinforcement in east China, gaining a foothold in central China, and actively preparing for west China.

2. One direction to take in the search for new coal resources in east China is beneath the region capped by the Cenozoic and the other direction is beneath various types of structures. Making breakthroughs in both these areas requires stronger coal field geological research work. In the early part of the 1990's, we will do comprehensive research according to structural demarcations and coal accumulation demarcations in China on the basis of coal field geological laws in large coal-bearing regions. In east China, this research will be combined with special research on gently inclined fracture structures in the coal fields of east China. The threads of the research will be examined and confirmed at various times by organizing geophysical exploration and exploratory drilling in an effort to discover several new coal resources. On this basis, we will carry out work on the third national coal field survey during the mid-1990's.

3. Reinforcing geophysical exploration work is an effective comprehensive exploration method for developing regions with the proper conditions. We should also take advantage of the potential for using geophysical exploration for coal formed beneath capping strata and beneath structures. We also should accelerate the pace of exploration and continue to create new experiences to enable a further reduction in the number of exploratory drilling projects. On the basis of breakthrough progress made in high resolution seismic exploration of minute geological structures which control coal fields, we are now involved in exploring lithologic prospecting and seeking new developments in revealing trends in thickness variations in coal seams. In addition, geophysical exploration will also be used as a work method for study in rather complex topographic conditions to expand the range of its adaptability and allow it to play a greater role.

4. Some coal fields in east China are located in large karst mining regions and some of the "lower group coal"

which is quite close to the limestone bedrock of coal systems cannot be mined because of water dangers. This resource, which has been used as "idle reserves," totals over 1 billion tons in the eastern part of the north China coal-bearing region alone. Utilizing it would certainly substantially reduce the resource shortage in east China. In contrast, most of the coal fields in central and west China are located in arid and deep water table regions, and the shortage of water resources has become one of the main factors restricting development of the coal industry. For this reason, controlling water in east China and finding water in central and west China are indispensable aspects of coal field geological exploration work. New breakthroughs are urgently needed in this area, both in theories and technologies.

Mining coal seams beneath thick capping strata in east China requires that outcrop coal pillars be left in place, which ties up considerable coal resources. We are preparing to study engineering geology conditions for Cenozoic capping strata on the basis of some previous experience and theoretical research achievements to take advantage of mining regions of different formational and burial categories in an effort to "liberate" some of these resources.

5. To meet the need for moving toward mining deeper areas in coal mines and the need to move toward deeper areas in east China to develop new resources, we must reinforce testing and research in ground pressure, ground temperature, and other areas. There also should be corresponding improvements in exploratory drilling equipment and exploratory drilling technologies to gradually transform the present technical situation in which 1,000 meter rigs are the main force by importing and developing drilling rigs with deeper dimensions as appropriate. We also should develop from the present mechanical drives and hydraulic vertical shaft drives toward fully hydraulic drives. Do research on matching technologies for adapting drilling to deep dimensions, arid areas which lack water, and other conditions to make fundamental changes in the technical situation in coal field exploratory drilling.

6. While doing good coal field exploratory drilling, we also should carry out comprehensive prospecting and comprehensive evaluation of other beneficial minerals in coal system strata and the surrounding rock, such as kaolin, bauxite, and various other types of minerals to expand the economic benefits and social benefits of coal field exploration.

Intensifying R&D of Coal Preparation

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[Article by Shan Zhongjian [0830 1813 0256], deputy director of the China Unified Distribution Coal Mine Corporation Production Bureau and professor-level senior engineer: "Rely on Scientific and Technological Progress, Strive To Develop Coal Preparation To Meet the Needs of National Economic Development"]

[Text]

I. The Current Situation in Developing Coal Preparation in China

For the past several years, China has made a major effort to develop coal preparation and processing and there have been breakthroughs both in output and technical levels which have put us into the ranks of the world's main coal dressing nations. This is particularly true concerning implementation of several important and scientific reforms on the basis of survey research to achieve rational utilization of coal resources which have further promoted development of the coal preparation industry.

1. China Has Entered the Ranks of the World's Main Coal Dressing Nations

For the past 40 years and especially since the 3d Plenum of the 11th CPC Central Committee, China has used restoration, expansion, new construction, technical transformation, importing advanced technologies from foreign countries, and so on to increase its coal dressing plants from 10 in 1949 to 163 in 1988. These include 98 coking coal dressing plants and 65 power coal dressing plants. The raw coal intake washing capacity has grown from 14.35 million tons in 1949 to 180 million tons in 1988, so in absolute terms China is in third place in the world following only the Soviet Union and the United States (see Table 1). Moreover, as industry has developed and technology has progressed, China's coal dressing plants have gradually moved toward larger scales, such as Pingshuo Coal Dressing Plant, which has a design yearly processing capacity of 15 million tons. We have 11 coal dressing plants which can handle 3 to 4 million tons a year, including Tianzhuang, Xinglongzhuang, Fengezhuang, and other coal dressing plants. We also have over 48 coal dressing plants with a yearly processing capacity of 1 to 2 million tons, such as Matou, Zhuzhou, Datun, and other coal dressing plants (Table 2). They have produced a situation in the coal dressing industry which has a full complement of technologies, matching equipment, integration of large and small scales, and flourishing development that has made China one of the world's main coal dressing nations.

Table 1. Some Primary Indices for Unified Distribution Coal Mine Coal Dressing Plants in 1988

Raw coal washed (million tons)	Coking coal washed (million tons)	Clean coking coal output (million tons)	Clean coal ash content (percent)	Profits (million yuan)
170	117	62.36	10.15	160

Table 2. Plant Category Comparisons for Coal Dressing Plants

Plant category (million tons/year)	Total	15	3-4	2-3	1-2	<1
Number of plants	163	1	11	10	48	93
Proportion (percent)	100	0.61	6.75	6.13	29.45	56.06

We have been concerned both with increasing quantities as well as improving quality. To deal with the needs of users, we have advanced technologies and rational technical flow processes to produce different product varieties and qualities, and we work toward conforming to the needs of users, targeting supplies toward outlets, and top prices for top quality to foster the greatest economic benefits and social benefits.

There are major variations in the quality of raw coal brought in for washing in China and the dressability of most of China's raw coal is coal that is hard to dress. This is particularly true for our main coking coals like rich coal and coking coal, most of which is extremely hard to dress coal. Although the ash content of raw coal brought in for washing has increased over the years and it is rather hard to dress, the ash content of cleaned coal in China has dropped each year, falling to 10.15 percent in 1988. The water content and sulfur content of washed cleaned coal in 1988 dropped to 11.63 percent and <1 percent, respectively, both of which met the requirements of users. Because of improvements in product quality, two washed and dressed products from coal dressing plants have now received two gold medals, five silver medals, and 38 Ministry of Coal Industry superior quality product designations, making them superior quality products which have gained the trust of users.

2. Coal Preparation Technologies Have Moved Up to Advanced World Levels

As the coal industry has developed and S&T levels have progressed, there have been obvious improvements in coal technical levels in coal preparation and breakthroughs have been made in the four areas of technical flow processes, preparation equipment, production indices, and management and administration. These have moved preparation technologies up to or almost to advanced world levels.

1) Technical Flow Processes

In the area of present choices of preparation methods and technical flow processes, China's 160-plus coal dressing plants have adopted various separation and dressing methods including heavy medium, jigging, flotation, shaking bed, and others according to local conditions.

At the end of 1987, the proportions of different coal preparation methods used in China were jigging 60 percent, heavy medium 23 percent, flotation 14 percent, and shaking bed and others 3 percent.

2) Preparation Equipment

Since the beginning of the 1980's, we have imported relatively advanced coal dressing equipment and technologies and developed quite a bit of Chinese-made large coal dressing equipment on our own, such as large inclined pulley heavy medium separators with a trough width of 4 meters and three-product heavy medium swirlers, large numerical control electromagnetic wind valve jiggers (24 and 35 square meters), jet swirl flotation separators and large 8, 12, and 16 cubic meter flotation separation machines, belted rolling presses 1, 2, and 3.5 meters wide, large 340, 500, and 1,050 square meter automatic pressure filters, 200 square meter vacuum filters, deep conical concentrators 5 to 7 meters in diameter and 8 to 10 meters high, and screening machines for various uses (such as probability screeners, equal thickness screeners, rotating probability screeners, string screeners, and so on). The characteristics of this new equipment include large capacities, low energy consumption, and high efficiency, which have created excellent conditions for domestic production and increased productivity of the preparation equipment, and larger scale, automation, and modernization in coal dressing plants.

3) Production Indices

For many years, leaders at all levels and engineering and technical personnel on the coal dressing production battlefront have made enormous efforts in the area of studying advanced things and creating levels. They have completed all production tasks stipulated by the state and attained relatively advanced technical economics indices. This is particularly true for several coal dressing plants which have attained quality standardization and modernization and have even more advanced qualities. They have created several products of various brands

with rather excellent quality that have been assessed as state or ministry superior quality products.

4) Management and Administration

To achieve scientific management and administration and enable enterprises to foster their optimum energy, create the greatest value, and attain maximum economic results, coal dressing plants adhere to these five principles: users' requirements as the foundation, maximum economic benefits as the goal, the economic contractual responsibility system as the nucleus, computerized management as the means, and market forecasts as the lifeblood.

3. Carry Out Scientific Reforms for Rational Utilization of Coal Resources

For the past several years, to make rational use of coal resources and promote development of the coal preparation industry, we have used a large amount of survey research and data analysis to carry out a series of important scientific reforms. From the results of trial implementation over the past 3 years, we have already achieved obvious social and economic benefits.

1) Trial Implementation of New Coal Classification Standards

In 1974, the State Central Standards Bureau entrusted the Ministry of Coal Industry and Ministry of Metallurgical Industry with reformulating new coal classifications to replace the "China Coal (Mainly Coking Coal) Classification Program" implemented on a trial basis in 1958. After over 10 years of joint research, and after being organized and passed the State Central Standards Bureau, they were implemented on a trial basis throughout China in October 1986. The new coal classifications have two advantages. One, they have advanced classification indices. The categories for bituminous coal, for instance, changed the past classification method which used the colloid layer y value as an index to using the more advanced international G value bonding coefficient as a classification index. Transmittance is also used as an index for young coal since it can clearly distinguish between lignite and long-flame coal.

The second major advantage is that rational classification methods can divide coal with extremely complex properties into a certain number of categories so that the same category has nearly identical properties and different categories of coal have rather substantial differences in properties. Four transitional coal categories were added to the classifications and the number of small categories was reduced and the number of large categories increased. This is particularly true for the coking coal category, which accounts for one-third of our new coal types. Some of the rich gas coal and gas coal in the past was replaced, which expanded our superior quality coking coal resources. This increased coal for coking mixtures for metallurgical users and increased economic benefits, and it provided the coal industry with an additional 100 million-plus yuan in benefits.

2) Formulation of Coal Utilization Standards Adapted to Our National Conditions

To rationally develop and utilize our coal and reduce waste, it is very important that coal utilization quality standards for China's main industries and mining region coal supply standards be formulated. The quality standard for coal used in each industry can provide a scientific foundation for formulating coal supply standards in mining regions, prices for coal resource use purposes, coal allocation and transport, and coal development and processing plans, and they can provide a reliable foundation for controlling and managing coal quality. To date, with the State Technical Supervision Bureau providing leadership and the Coal Science Academy serving as the main force, we have formulated quality standards for the coal used in eight industries (i.e., coal used for metallurgical coking, coal used for casting coking, coal used to make synthetic ammonia, coal used as powdered coal for power generation boilers, coal used in rotating cement kilns, coal used for fixed bed coal gas generation furnaces, coal used for steam locomotives, and anthracite coal used for spraying in blast furnaces).

All mining regions can use the industrial coal standards (including product varieties, regulations, quality, etc.) to carry out technical transformation of the relevant equipment and produce marketable products to benefit both coal producers and users.

3) Basically Eliminate Direct Sales of Raw Coal, Gradually Achieve Product Optimization

In 1980, direct sales of raw coal in unified distribution coal mines accounted for 45.69 percent of the total commodity coal volume. The coal supplied to users had a high ash content and few coal varieties. This was incorrect and caused serious waste. For this reason, we have been focusing on the question of eliminating direct sales of raw coal. According to statistics, the Ministry of Coal Industry provided 48.63 million yuan in subsidies as technical measure expenditures for raw coal between 1979 and 1988 to build 153 screening plants or simple coal dressing plants. This produced a net increase of 169 million tons in the amount of coal screened in 1988 relative to 1979 and direct sales of raw coal in 1988 were just 7 percent of the total volume of coal sales. Screening raw coal (or simple preparation) increases income by 2 yuan per ton, so the total increase in income in 1988 was 340 million yuan. Along with eliminating direct sales of raw coal, we also improved coal quality. For example, the ash content of commodity coal from unified distribution coal mines in 1988 was 18.82 percent, a reduction of 5.72 percent over the 1979 figure of 24.54 percent. This raised coal quality by six grades.

Coal mine screening plants are widely using Chinese-made equal-thickness screeners, probability screeners, rotating probability screeners, string screeners, and other dry method raw coal screening and separating equipment. There are now about 400 pieces of screening and

separating equipment in operation. To meet the needs of raw coal market conditions, we also started from real conditions to develop simple coal washing plans using simple preparation technologies which require few investments and produce results quickly by extending inclined trough separators, jiggers, and water medium swirl devices as the primary equipment. The development of screening or simple coal dressing plants has brought obvious changes to the commodity coal structure.

To achieve fully rational utilization of coal resources, we have scientifically formulated product optimization programs. At Datong Mining Bureau, Jincheng Mining Bureau, Chongqing Coal Industry Company, Yima Mining Bureau, and other places we have actively developed work to optimize coal product structures and achieved obvious results.

4) Set Prices for Power Coal According to Heat Output

In the past, China consistently used ash content as the main quality standard to set prices for coal products. As reforms in the economic system have developed and technical levels in coal using units have continually risen, we have had to reform the method of setting prices according to ash content by implementing a method in which the price for power coal is set according to heat output. Setting prices for power coal according to heat output can achieve greater identity between its use value of price and unify quality and pricing standards for coal mines and users. This helps social energy conservation and aids in improving the economic benefits for enterprises and society.

China has made definite achievements in coal preparation and entered the ranks of the world's big coal washing nations. However, in view of the situation in most coal dressing plants at present, there are still many problems and discrepancies both in comparison to advanced plants in foreign countries and in comparison to several new coal dressing plants inside China. They are manifested primarily in:

A low proportion of raw coal being washed. In terms of the absolute value of raw coal being washed, although China is still a big coal dressing country, the proportion of coal being washed is still very low. Because of the capital shortage and our long-term custom of directly using raw coal, the fact that growth in raw coal output over the past several years has exceeded the rate of increase in the amount of raw coal being washed has caused the proportion being washed to consistently hesitate at the 17 to 19 percent range. After current plans are implemented, the proportion being washed in the year 2000 will only increase to about 21 percent. It should be pointed out here that the main reason for the very low proportion being washed in China is that the proportion of coal from local coal mines being dressed is too small. Raw coal output from local coal mines in 1988 was 545 million tons, but only an estimated 10 million tons of this raw coal was washed. Another important reason is that capital construction investments for coal dressing plants have been too small.

Worsening coal mine production conditions and increasing mechanization levels in coal mining have led to continual decreases in the raw coal output being washed. There have been comprehensive increases in the ash content, water content, sulfur content, gangue content, and non-coal content of raw coal. Added to the increasingly higher demands of users concerning coal quality, this compels us to make major efforts to develop preparation and increase the amount of coal being washed to help improve coal quality, reduce sulfur content, protect the environment, conserve energy and transport, and increase thermal efficiency.

We lag substantially behind foreign countries in the area of the quality of washed and cleaned coal. The equipment in most coal dressing plants is outdated, the quality of the coal is poor, there is more hard-to-dress coal, and existing technologies cannot adapt to production requirements, so problems of poor quality, few product varieties, and less than complete marketability persist for washed and dressed products. The ash content of coal sold for use as coking coal averaged 10.15 percent in 1988 and the ash content from some coal dressing plants was as high as 12.5 percent. The ash content of cleaned coal in advanced industrial nations is generally 5.5 to 8 percent, so we lag substantially behind. The average water content of cleaned coal was 11.63 percent in 1988, whereas the water content of cleaned coal in foreign countries is generally 6 to 8 percent. The sulfur content of cleaned coal used for coking is generally less than 1 percent, but there are still a few coal dressing plants whose coal products have a sulfur content over 2.5 percent. Moreover, power coal cannot use a greater variety of products to take advantage of its utilization. Some 80 percent of the coal supplied to the chemical industry is not washed and dressed. Problems of outdated equipment and low automation levels persist in some coal dressing plants.

II. Prospects for Developing Coal Preparation

As the primary industries of China's entire national economy develop and coal output, which accounts for 75 percent of our energy resource consumption, also increases, the coal dressing industry which is closely related to the iron and steel industry also must grow along with it. Based on the requirements of iron and steel development plans as well as coal requirements in the chemical industry, exports of cleaned coal, and so on, the amount of cleaned coal required in the year 2000 will be about 164.2 million tons.

On the basis of the requirements in each of the primary industrial sectors mentioned above the goal for coal preparation in 2000 should be:

Output:

Cleaned coal output for coking coal should reach ....137.2 million tons

Output of power coal should be......60 million tons

Quality:

Ash content of cleaned coking coal..........9 percent
Water content of cleaned coking coal.....10 percent
Ash content of commodity coal.............18 percent
Water content of commodity coal............9 percent
Gangue content of commodity coal.....0.15 percent

Efficiency:

Preparation efficiency....................Over 90 percent
Productivity..........................Over 25 tons/manshift

Automation:

Establish two highly automated Chinese-style modernized coal dressing plants

The following measures must be adopted to achieve these goals.

First, we must increase the proportion washed, try in every way possible to expand the amount of raw coal washed, and try to meet the demand for cleaned coal in all industrial sectors to the greatest possible extent. On the one hand, we should increase the capacity for washing coking coal. On the other hand, we should increase the amount of power coal that is washed. We must eliminate direct sales of raw coal by the year 2000 and we should decrease the proportion of existing screening plants. Actively developing preparation in local coal mines and township and town coal mines is an important way to increase the proportion of coal that is washed.

To increase the proportion that is washed and increase washing capacity, besides building several new coal dressing plants, we also should focus on transformation and expansion projects in existing coal dressing plants, concentrate on intensive reforms, achieve better matchup and perfection reforms, and fully exploit the maximum potential in existing coal dressing plants.

In the area of raising scientific management levels, we actively extended scientific management based on the principle of maximum economic benefits to replace the past method of managing production which was concerned only with the principle of maximum recovery rates, and we should improve coal quality and equipment levels in coal dressing plants.

Formulation and implementation of rational economic policies is the basic guarantee for promoting the development of coal dressing. In the future we should rely on policies and S&T progress, rely on exploiting potential and innovation, and rely on opening up capital channels to continually perfect all economic policies and price policies related to coal dressing to promote flourishing development of the coal dressing industry.

Comprehensive Use of Coal Resources

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[Article by Ming Zhong [2494 1813], general manager of the China Coal Comprehensive Utilization and Development Company: "Comprehensive Utilization of China's Coal Mine Resources"]

[Text] China was one of the first nations in the world to extract and utilize coal resources, but comprehensive development and utilization of coal mine resources is something that we have only been doing in the past 40 years. Over the past 40 years, comprehensive development and utilization of China's coal mine resources has mainly been focused on four areas: 1) Comprehensive utilization of coal; 2) comprehensive development and utilization of coal's paragenetic and associated mineral products; 3) comprehensive utilization of coal gangue and coal slurry; and 4) comprehensive utilization of stone coal.

I. Comprehensive Utilization of Coal

Coal is China's number one energy resource. Rational development and utilization of coal plays an important role in developing the national economy and raising the people's living standards. For this reason, we are actively studying coal conversion technologies and making major efforts to develop shaped coal, coking, gasification, liquefaction, and products which use coal as a raw material. We have made several scientific research achievements and obtained rather good economic benefits and social benefits in production practice.

1. Shaped Coal

Industrial development creates growing demand for lump coal and coke. However, an increasing degree of mechanization in coal mining reduces lump coal output and increases output of powdered coal. Moreover, China consumes 150 million tons of coal annually for civilian uses and most of it is burned as loose coal which has a low thermal efficiency and causes substantial pollution. For this reason, effective utilization of shaped powdered coal to replace lump coal and loose coal has become a topic which we are continually exploring and studying.

Before liberation, China merely relied on manual labor to produce small amounts of coal briquets and there was no coal shaping industry. After liberation, we began studying coal shaping technologies, especially over the past 10 years. We overcame a whole series of key technical problems with bonding agents, igniting agents, smokeless combustion of bituminous coal, new types of high efficiency stoves, shaping machinery, stove-front shaping, and so on. Besides coal briquets and honeycomb coal for civilian uses, we have also successfully developed several ten product varieties including igniting honeycomb coal, locomotive coal, railroad tea stove shaped coal, boiler shaped coal, aviation shaped

coal, hand stove coal briquets, chafing dish shaped coal, and others. Coal shaping technologies are now being universally extended and utilized in China and shaped coal output has reached 28 million tons. The unified distribution coal mine system has now built 138 coal shaping plants with a yearly design production of 1.08 million tons. Moreover, we have already reached agreements or arrangements with many countries concerning the question of patenting China's coal shaping technologies.

2. Coal Coking

China holds fourth place in the world in coke output and our industry produces over 50 kinds of coking chemistry products. The coking industry has developed rather quickly since the nation was founded. China now designs and builds coking ovens with 6 meter high carbonization chambers and a volume of 38.5 cubic meters, and we have the capability of designing 8 meter high carbonization chambers.

To deal with the characteristic of the rather large amount of gas coal and weakly bonded coal in China's coking coal, we began to expand research on coal used for coking in the 1950's and have now attained a rather high level. The amount of weakly bonded coal used in the mixture is over 50 percent and we have changed the tradition of using "gas, rich, coking, and lean" coal for the coal mixture used for coking.

Tamped coking technologies have an obvious advantage for expanding coking coal resources. China has already built six tamping-style coking ovens and accumulated rich production experience.

Based on the characteristics of China's coking coal resources, Chinese research personnel have proposed evaluation methods and V'-G charts for the coal used for coking which have played a guiding role in the coal used for mixing in coking plants. To meet the needs of users at Baoshan Iron and Steel Company, Chinese research personnel studied a coal mixing program using eight coal varieties like Yanzhou gas coal and others and made coke which can be used in large modernized blast furnaces.

In addition, in the area of coking techniques and technologies, China has developed lignite two-stage coking and cold-pressure and hot-pressure coking technologies. We have studied and improved casting coke and iron alloy coke production technologies, which has promoted technical progress in the machine manufacturing industry.

3. Coal Gasification

Coal gasification technologies developed substantially in China. China now has over 4,500 fixed-bed normal-pressure gasification ovens which use coal to produce low heat value fuel gas and synthetic gas. China's medium-sized and small synthetic ammonia plants have been using fixed-bed coal-water mixture gasification ovens for quite some time to produce gas as a raw material for the chemical industry. There have also been developments in normal-pressure fluidized bed gasification technologies to produce synthetic gas. The first generation of Lurgi pressurized gasification ovens imported in the 1970's are still in normal operation. China's coal-water mixture gasification ovens have always used lump anthracite as a raw material. We subsequently studied and successfully used carbonized coal briquets as a substitute for lump anthracite. Moreover, Chinese research personnel have also developed a coal shaping technique using humate as a bonding agent. Powdered anthracite is used to make shaped coal for use in producing gas.

To use powdered coal as a raw material for gasification, China has undertaken research on airflow bed powdered coal normal-pressure gasification technologies. We completed a synthetic ammonia industry gasification oven with a 5,000 tons/year capacity in 1983 and experimented with Longkou lignite. We met the design requirements of producing 1,800 Nm^3/hour coal-water mixture gas and the $CO+H_2$ content of the goal gas was >80 percent. The equipment functioned excellently.

China has rich resources of lignite and high volatility bituminous coal. Extracting coal gas using this type of coal as a raw material via total gasification is an important route for developing urban coal gas in China. Over the past several years, China has adopted fixed-bed pressurized gasification and two-stage oven gasification to develop urban coal gas. Shenyang has now completed a pressurized gasification plant with a scale of 0.54 Mm^3/day one in Lanzhou and a 1.6 Mm^3/day one in Yilan.

To adapt to the development of urban coal gas, China began studying fixed-bed pressurized gasification technologies in the 1960's. We completed a 1.12 meter diameter pressurized gasification pilot facility in 1964 and built a 0.65 meter diameter experimental pressurized gasification facility in 1984. China has also designed and manufactured a 2.8 meter diameter fixed-bed pressurized gasification oven and is now conducting gasification experiments.

To meet the need for developing coal gas in medium-sized and small cities and in mining regions, China is studying water-coal gas two-stage gasification, long-flame coal gasification, and water-coal gas partial methanization. Experiments with a 1.6 meter diameter water-coal gas two-stage gasification oven began in 1986 and it has been used to make moderate heat value coal gas using Fushun and Benxi coal, with gratifying progress.

Research on the second generation of gasification technologies is now proceeding smoothly. For coal-water mixture pressurized gasification, we have now completed a model experiment with a 20 kilograms/hour processing capacity and achieved rather good results at a pilot facility with a 1.5 tons/hour of coal scale. The carbon conversion rate is as high as 95 percent, the cold

coal gas efficiency is 66 percent, and the effective $CO+H_2$ gas content is as high as 76 percent. Basic laboratory research on powdered coal ash fusing fluidized bed gasification to produce low heat value coal gas has been completed and we have produced coal gas with a heat value of 800 to 1,000 kcal/Nm^3 using anthracite and high ash content bituminous coal in an experimental oven with a coal processing capacity of 1 ton/day.

4. Coal Liquefaction

1) Direct Coal Liquefaction

From the 1950's to early 1960's, China did basic research on coal liquefaction technologies. In the early 1980's, we again began studying direct liquefaction of coal in China and did research on direct hydrogenation conversion of coal into a clean liquid fuel. We cooperated with Japan in building a small experimental continuous liquefaction facility with a 0.1 ton/day capacity. We imported a small 5 kilograms/hour continuous liquefaction experiment device from West Germany and have now placed it into operation. We also established and perfected testing measures. Moreover, we have made valuable progress in selecting liquefaction catalysts, optimum technical conditions for liquefaction, liquefaction distilling and processing methods, and other areas. We have used Chinese-made hydrogenation and reforming catalysts to make high quality gasoline with an octane number of 82.5 and chemical industry raw materials rich in arene.

2) Indirect Coal Liquefaction

Over the past several years, China has made substantial progress in research on improving the Fischer-Tropsch synthesis method. On a foundation of completing basic research in the laboratory and experiments in a 50 mm diameter monotube, we did intermediate testing in synthesizing 100 kilograms of oil in daily output. The synthetic gas produced in a small coal gas oven was put through two-stage catalysis and underwent synthesis and modification at a specific pressure to produce gasoline, coal gas, and other products.

In the area of substituting coal-based fuels for liquid fuels, several ten units in China are now experimenting with substituting methanol for gasoline. They have achieved very good results using M15 and M100 as a gasoline substitute.

5. Developing New Products Which Use Coal as a Raw Material

Continual development in the chemical industry and pharmaceutical industry and continual increases in environmental protection requirements generate growing demand for activated carbon. To meet the needs of national economic development, we have organized experiments and inspected and passed "pulverizing and shaping, carbonization, and activation technologies" suitable for use in coal-based active carbon. There has also been flourishing development of coal-based activated carbon. The coal system alone has already built 15 activated carbon plants with a design yearly output capacity of almost 15,000 tons. There has also been progress in using coal and its derivatives to make carbon fiber and carbon materials technologies.

II. Comprehensive Utilization of Low Heat Value Fuels

1. Power Generation With Coal Gangue and Coal Slurry

China produces over 1 billion tons of coal yearly, so of course we have a considerable amount of coal gangue. Surveys indicate that as of the end of 1984, China had coal gangue stocks of 1.3 billion tons which took up more than 95,000 mu of land. We are also dumping 130 million tons of new gangue every year and taking up over 10,000 mu of land. When large amounts of coal gangue are stored for long periods, SO_2 gas emitted by spontaneous combustion causes severe environmental pollution and poses dangers for both humans and crops. For this reason, comprehensive utilization of coal gangue has become an important part of comprehensive utilization of China's coal mine resources.

For the past 10 years, we have invested enormous amounts of manpower and materials in the area of comprehensive utilization of coal gangue for such things as resource surveys, establishing databases, basic theoretical research, applied technological research, combustion mechanisms, boiler development, structural evolution of minerals during the combustion process, the use value of slag, and so on. We have done a great deal of scientific research and experiments and accumulated rich experience. We have made many achievements and determined a set of technical lines that are perfectly matched and suited to China's national conditions. The main content of this line is technologies for using coal gangue to generate power and technologies to use coal gangue to manufacture construction materials.

The emergence and development of coal gangue power generation in China are closely related to the development of fluidized bed combustion technologies in China. In the early 1960's, China first conducted small-scale industrial fluidized bed boiler combustion experiments and attained success. In the early 1970's, we also went further in organizing and developing coal gangue fluidized bed combustion experiments and established cold and hot state experiment units to study fluidized bed heat surface heat transfer, wear, pollution, and other areas, and we explored ignition, combustion mechanisms, and ways to raise thermal efficiency. At the same time, we used fluidized bed boilers which burned 3 tons/hour and 6 tons/hour using coal gangue and derived practice and theories in design and operation. Subsequently, in 1975, Yongrong Mining Bureau's power plant successfully converted a 20 tons/hour coal-fired boiler to a power generation fluidized bed boiler which burned coal gangue. This opened a new situation in coal gangue power generation in China. In the late 1970's, a

130 tons/hour coal gangue power generation fluidized bed boiler manufactured by Shanghai Boiler Plant was installed and put into trial operation at Jixi Mining Bureau's power plant. This moved China in the ranks of advanced world nations in the area of single unit scale for fluidized bed boilers. Since the 1980's, China has made fluidized bed combustion technologies a state-level focal project for attacking key S&T problems and done planned and organized experimental research on several major technical questions. During the Sixth 5-Year Plan, we organized over 30 units for joint attacks on key S&T problems. Besides outfitting and perfecting 130 tons/hour and 35 tons/hour power generation fluidized bed boilers, we also developed three 10 tons/hour industrial fluidized bed boilers. We also did a great deal of experimental research on fluidized bed combustion of coal slurry, fluidized bed combustion and desulfurization of high-sulfur coal gangue, and other technologies and attained gratifying results. During the Seventh 5-Year Plan, on the basis of bubble fluidized bed technologies, we also arranged research on circulating fluidized beds, pressurized fluidized beds, coal slurry power generation and oil shale power generation boilers, and other new technologies.

Perfection and maturation of 35 tons/hour coal gangue power generation fluidized bed boilers and the matching technologies resulted in rapid development of coal gangue power plants in China. To date, China has built 20 coal gangue power plants with a total installed generating capacity of 189.4 MW. By the end of 1990, the total capacity in China's coal gangue power plants will increase to 430 MW.

At present, the coal industry is mainly following the development tide of China's fluidized bed combustion technologies. Coal gangue power generation is indicative of the high level China has attained in fluidized bed combustion technologies for low heat value fuels. Compared with foreign countries, China still maintains a certain advantage in quantity and operating experience in coal gangue power generation.

2. Using Coal Gangue To Make Construction Materials

Coal gangue is symbiotic with coal system strata and is a sedimentary rock. Surveys and data analysis indicate that the chemical components and mineral constituents of the coal gangue in most of China's mining regions is similar to clay. After many years of comprehensive technical development, coal gangue has now entered nearly all realms of China's construction materials industry, including cement, bricks and tile, ceramics, light aggregate, foundry stone, aerated concrete, building blocks, and so on. Its role is especially prominent in cement and bricks and tile.

1) Using Coal Gangue To Make Cement

China has done considerable research on using coal gangue to make cement. First, we did a survey of all of China's coal gangue resources to determine the amounts in storage and amounts being dumped. We also analyzed the chemical components of China's coal gangue and analyzed its mineral constituents, measured its plasticity and volcanic ash properties, and established a database. At the same time, we organized large-scale attacks on key technical problems and made several achievements in theories and applied technologies. This revealed the activation mechanisms of coal gangue, determined principles for making coal gangue ash and slag activation, and gradually formed a theory and technology for cement production suitable for China's vertical kilns. Examples include theories and technology on substituting coal gangue for clay as a mixing agent, theories and technology for low temperature firing of highly saturated specific combination mineralizing agents, technologies for making cement composite materials using fluidized bed boiler drying and fluidized bed slag. Coal gangue cement has developed rapidly in China under scientific guidance.

There are now over 50 coal gangue cement plants in China's coal system alone with a total production capacity of more than 2 million tons. Their products include silicate cement, common silicate cement, volcanic ash cement, quick-setting cement, large dam cement, and other special types of cement. The technology for substituting coal gangue for clay is suitable for use with $\varphi 2.5$ X 10 meter, $\varphi 2.2$ X 8.5 meter, and $\varphi 1.7$ X 7 meter vertical kiln technologies, and it has been successfully used in large rotating kilns. Practice has proven that using coal gangue as a substitute for clay and using fluidized bed boiler slag to make composite materials can result in clay conservation of 100 percent and energy conservation of 15 to 30 percent. It also improves product quality, improves the soundness of cement, and has extremely obvious economic benefits.

2) Using Coal Gangue To Make Bricks

In the early 1960's, research personnel in China's Sichuan Province successfully studied the use of coal gangue to make bricks and obtained industrial production experience in Yongrong Mining Bureau. This promoted burgeoning development of coal gangue brick production in China. According to statistics from China's construction departments, China now produces about 40 billion coal gangue bricks each year. The coal system alone has over 200 coal gangue brick plants with a yearly production capacity of 1.8 billion pieces. Coal gangue bricks have now become an important part of China's wall materials and they are playing an enormous role in the national economy.

Practice has proven that coal gangue bricks can replace clay bricks and that they are superior to clay bricks in strength, corrosion resistance, and other properties. Thus, they have been recognized by society and have been formally included in state "sintered brick" standards.

Following the widespread and burgeoning development of coal gangue bricks, breakthroughs also were made in using high sulfur coal gangue to make bricks. Chinese

research personnel utilized the principle of spontaneous firing coal gangue clinker-free cement blocks to successfully produce spontaneous firing high sulfur coal gangue bricks. The properties of the bricks were excellent, above grade 200, and the highest were about grade 400. This was very important for China's high sulfur coal regions which have relative shortages of wall materials.

Traditional Chinese style bricks and tiles are a source of pride for China, and this technology has remained more or less unchanged for several thousand years. However, after the successful research on using coal gangue to make bricks, we achieved people's long-term desire for "sintering bricks without using coal and making bricks without using clay," and it shook traditional brick-making techniques.

III. Comprehensive Development and Utilization of Coal's Symbiotic and Associated Minerals

China has widely distributed coal fields, very thick coal-bearing formations, and a full complement of coal formation periods. For this reason, there are abundant symbiotic and associated mineral resources in China's coal fields, including gas, kaolin, bentonite, high-alumina clay, oil shale, graphite, pyrite, perlite, diatomite, vacuolite [?], magnesite, barite, talc, feldspar, gypsum, natural coke, salt, phosphorous, arsenic, jet, amber, silicified wood, fossils, and so on. It has now been proven that there are over 40 elements in a symbiotic and associated state of preservation with coal and its surrounding rock, and some of them are products which are in shortage and sell well in China and foreign countries. Some reserves account for a substantial proportion in China. Nearly all our high-alumina clay, for example, was produced in coal fields. For this reason, comprehensive development and utilization of coal's symbiotic and associated minerals is now seen as the second pillar of China's coal industry. However, in this area, with the exception of developing and utilizing some gas, pyrite, high-alumina clay, kaolin, and oil shale, the other minerals basically have not been developed for technical, capital, and other reasons.

1. Gas Development and Utilization

Gas is a high heat value, clean, and convenient to use energy resource. China's coal mines have extremely rich gas resources. According to incomplete statistics, China has gas reserves of about 238.4 billion cubic meters. In China's existing mines, there are 290 high gas mines, 88 of which discharged gas during 1988. The annual amount of gas discharged was 360 million cubic meters.

Beginning in the 1980's, with support from relevant state departments, gas developed from purely being discharged for safe production purposes to discharging and utilization. At the same time, we solved technical problems like equilibrium discharging, reserve balancing, computing, stoves, and so on. The amount of gas being utilized has risen every year as a result. In 1980, we utilized 150 million cubic meters and in 1988 this increased to 253 million cubic meters. The utilization rate rose from 50 percent to 70 percent. There has also been continual growth in utilization methods including gas power generation, manufacturing carbon black, civilian uses, and so on. There are now three plants which use gas to make carbon black that have a yearly production capacity of 1,500 tons. A gas power generation plant is under construction and will have an installed generating capacity of 3 MW.

2. Coal System Pyrite Recovery

Statistics indicate that China produces over 100 million tons of coal with a sulfur content higher than 2 percent each year and dumps over 20 million tons of high sulfur coal gangue. The total amount of pyrite in the high sulfur coal that China produces each year is exactly equivalent to China's yearly output of iron sulfide. Moreover, most of China's high sulfur coal comes from deep coal seams and as our coal output has risen, the average sulfur content of China's coal has risen along with it every year.

Although China's coal system is very rich in pyrite, little of it is now being utilized. We have now built 18 iron sulfide recovery workshops in China with an annual production capacity of 500,000 tons. We plan to build 13 more during the Eighth 5-Year Plan with a capacity of 90,000 tons. By 2000, China plans to have a total iron sulfide recovery capacity of 3 million tons in our coal system. At present, because of rapid development of coal system pyrite recovery, like the chemical industry and nonferrous metals industry, coal mines are now acknowledged as one of the three main sources of pyrite in China.

3. Kaolin Development and Utilization

Most kaolin found in China's coal fields is sedimentary kaolin in coal-bearing formations. It is often found in coal system strata from five eras, and the reserves are large and of good quality. The kaolin of most is over 90 percent and can reach 98 percent in the purer ones. Moreover, crystallization is rather good in most and it is sequential structure authigenic kaolinite. The mineral seams are generally 10 to 50 centimeters thick and the thicker ones can exceed 1 meter. The strata positions are stable and their distribution may cover several 1,000 to several 10,000 square kilometers.

At present, Pubai, Xuzhou, Datong, Huabei, and other coal mines are doing different development experiments and utilization research on kaolin in their respective mining regions that have enabled widespread utilization of kaolin in the ceramics, plastic, rubber, high temperature paint, laundry detergent, and other industrial sectors. Breakthrough and gratifying progress has been made in experimental research on papermaking coatings.

4. Development of High-Alumina Clay

Nearly all of China's high-alumina clay is produced in coal fields. Producing areas are concentrated and contain rich reserves. Moreover, most is located in shallow parts of coal fields and thus is easy to extract. Kailuan

Mining Bureau has a yearly bauxite production capacity of 200,000 tons and its products are sold throughout the world. It is one of China's biggest bauxite producing regions.

China exports several 100,000 tons of high-alumina clay every year. It holds third place among our export mineral products, following only petroleum and coal.

IV. Comprehensive Development and Utilization of Stone Coal

Stone coal is the remains of early Paleozoic lower organisms. Repeated biochemical action and physiochemical action turn it into a sedimentary rock that looks like stone on the outside but can be burned. The results of comprehensive surveys indicate that China has total stone coal reserves of 61.8 billion tons, mostly located in provinces south of the Chang Jiang. Its heat output is generally 800 to 2,000 kcal/kg and it has over 60 associated elements. There are 10 varieties of industrial grade, including vanadium, molybdenum, copper, cadmium, uranium, silver, rare earths, and others. Among them, vanadium is the most widely distributed, and it has the highest average grade. We have total reserves (V_2O_2) of 117 million tons, more than total prospective reserves in all other countries of the world.

China's Jiangnan [area south of the Chang Jiang] region, which has a coal shortage, has a history of several 100 years of using stone coal as a fuel to fire lime. However, burgeoning development of stone coal extraction and comprehensive utilization is a thing of the past 10-plus years. For the past 10-plus years, because of the needs of industrial and agricultural production and development, there have been continual improvements in stone coal combustion technologies and vanadium extraction technologies. Stone coal has become an important fuel for industrial boilers in this region and a raw material and fuel for construction, and it has become an important source of metallic vanadium in China.

1. Stone Coal Combustion Technologies

The key to using stone coal as a fuel for industrial boilers is combustion equipment. Shelf-tube boilers are a type of boiler created through summarization in practice by the people of Zhejiang Province. They burn stone coal with a heat output of 1,000 kcal/kg in lumps about 50 mm in size. This type of boiler has a simple structure and is easy to manufacture. It employs natural ventilation and does not require an air blower, air pump, or pulverizing equipment. Several hundred units have now been extended and utilized in Zhejiang Province. They are widely used in collective cafeterias, the food and beverage service industry, and township and town enterprises.

In the late 1960's, China began refitting and designing stone coal fluidized bed boilers and broke through the barrier of burning 1,000 kcal/kg and under stone coal in fluidized bed boilers. This expanded the application routes for low heat value fuels and laid a foundation for stone coal power generation.

In the early 1970's, we successfully used fluidized bed boilers that burned 1,000 to 1,500 kcal/kg stone coal to generate electricity and made a contribution to using low heat value fuels in fluidized bed boilers to generate power. Geyang Stone Coal Power Plant built subsequent to this has operated stably for a long period and received attention from the state.

2. Extracting Vanadium From Stone Coal

Metallic vanadium is an important industrial material with a wide range of uses and excellent properties. The amount of vanadium sold worldwide has grown every year for the past several years.

Shortly after the nation was founded, China had no vanadium extraction industry. There has been burgeoning development of scientific research and production for extracting V_2O_2 from stone coal over the past 10-plus years. We have developed several different vanadium extraction techniques. Among them, the sodium fusion vanadium extraction method is widely used and industrial experiments with acid method vanadium extraction are now in progress.

China has now built 29 stone coal vanadium plants with a design capacity of 2,580 tons and another seven vanadium plants with a design capacity of 700 tons are now under construction. By the end of 1990, China will have built 36 stone coal vanadium plants with a design capacity of 3,280 tons.

V. Conclusion

Comprehensive utilization of coal mine resources has a rich content, broad prospects, and profound significance. In China, comprehensive development and comprehensive utilization of our resources as well as environmental protection are a national policy. We are very confident that through our continued efforts and close cooperation with foreign friends, the cause of comprehensive utilization of China's coal mine resources will certainly develop more quickly.

The Rise of Coal Mining Equipment Manufacturing

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[Article by Men Yingchun [7024 6601 2504], manager of the China Coal Mine Machinery and Equipment Company and professor-level senior engineer: "The Rise of China's Coal Mine Machinery Manufacturing Industry"]

[Text] Development of the coal mining industry has been accompanied by gradual development and growth in the coal mine machinery manufacturing industry. In the 40 years since the nation was founded, the coal mine

machinery manufacturing industry has formed a systematic, integral, and matching small industry with a basically rational deployment throughout China and it has become a technical equipment sector of the coal industry. Its strength and scale in the non-mechanical electronics industry is rather substantial. At present, the coal mine machinery industry has one national company, six regional companies, and three specialized companies. It includes 57 key plants and 100 additional plants included in plan administration, and another nearly 100 network point matching plants which have formed a yearly manufacturing capacity of over 300,000 tons of special purpose coal mine equipment. China's coal mine machinery manufacturing industry produced over 460 types and 270,000 tons of coal machinery products in 1989 which basically guaranteed coal mine production requirements.

Since the implementation of reform and opening up in the 3d Plenum of the 11th CPC Central Committee, and especially since 1985, we have used investments and loans to complete over 50 import and key transformation projects. We now have over 15,000 metallic cutting machine tools, over 2,000 pieces of forging press equipment, and over 200 pieces of smelting equipment. This includes several modernized processing centers, numerical control machine tools, deep hole boring machines, precision gear processing equipment, numerical control cutting and photoelectric tracking cutting machine tools, hot die precision forges, circular chain production lines, carrier catalysis component production lines, and other technical processing measures at advanced world levels. We also have testing measures and precision measurement devices with complete product functions.

Almost all plants have their own forces and organizations for developing products. They are closely concerned with new international trends in coal mine machinery product development and regularly track changes in user demand structures. They also maintain close relationships and cooperation with scientific research academies and schools. The coal mine machinery manufacturing industry has over 5,000 senior and mid-level technical personnel and over 1,000 advanced technical workers.

By relying on their enormous scientific research and design forces, advanced technical equipment, quality assurance systems, and mature technical workers, they supply China's coal mines with 400 to 500 types of coal machinery products of various specifications and models. These include 600 kW chainless traction dual roller coal extractors, large extraction height and high support strength hydraulic supports, apron conveyors, belt conveyors, coal loaders, load transferrers, pulverizers, hoists, safety instruments, metal support products, special purpose mine equipment, mine lamps, electric coal drills, electric rock drills, blast-proof electric motors, electric and electrical control equipment, single unit hydraulic supports, emulsion liquid pumping stations, coal washing, dressing, and processing equipment, coal field geology equipment, mine construction equipment, and other products. They also provide some products for the metallurgical, construction materials, power generation, textile, and other industries. Technology imports, cooperative manufacturing, and technical transformation have been used to make substantial improvements in technical levels of coal mine machinery products. In the area of fully mechanized mining equipment, coal mining machinery durability experiments now commonly reach 1,000 hours and coal extractors used for 1.3 to 4.5 meter gently inclined medium thickness coal seams basically can satisfy requirements. Hydraulic supports can now be designed according to users' requirements and we already have hydraulic support products with a working resistance of 1,000 tons and an extraction height of 4.8 meters. Multi-slice wire mesh laying supports, rooflight supports, and steeply inclined supports are now being produced in large numbers. The coal haulage volume for apron conveyors is 900 tons/hour and the conveyors can transport about 1.2 million tons of coal. They also have side dumping, sealed bottoms, dual speed drives, and other functions. Load transferrers, pulverizers, emulsion liquid pumps, power transformer stations, switches, and so on are now basically matched up. In the area of tunneling equipment, we have now achieved domestic production of cooperatively manufactured AM-50 and S-100 tunnelers using imported technology. In the area of safety equipment, with the exception of continuing to import certain components for gas sensor components, TF-200 environmental monitoring and transmission systems, bump pressure and other comprehensive monitoring systems as well as numerical control loggers for which we imported technologies, we can now basically design and manufacture them. Over 40 of these products have now received state quality awards and over 80 have received ministry and provincial superior product designations.

The coal mine machinery manufacturing industry occupies a decisive status in China's progress toward mechanization and modernization in the coal industry, and its scale and level are important indicators for evaluating coal S&T levels and developing reserve strengths. The coal mine machinery manufacturing industry is the chief of staff and medium for converting S&T into coal forces of production and an effective measure and route for reducing the intensity of labor for workers, improving the working environment, and guaranteeing safe production. The ability of China's coal output to increase by several 10 million tons every year during the 1980's, the obvious improvement each year in safety conditions, and yearly increases in productivity have been achieved mainly by depending on the coal mine machinery manufacturing industry's continual supply of appropriate and reliable equipment to coal mines. Increased amounts of coal mining equipment and improvements in equipment levels have now pushed the degree of mechanization in coal extraction in unified distribution coal mines to 60.1 percent in 1989. The degree of fully mechanized coal mining was 35.41 percent and the degree of mechanization in tunneling has now reached

56.85 percent, including 7.38 percent in fully mechanized tunneling. Of the fully mechanized mining equipment for work faces which have achieved yearly output in excess of 1 million tons, 90 percent was supplied by Chinese coal mine machinery manufacturing plants.

While continually meeting the needs of coal mine users, we have actively opened up international markets and strengthened friendly relations. We have been selling hydraulic components, mine lamps, circular link chains, electric motors, single unit hydraulic supports, and other products in foreign countries. We shipped several hydraulic supports for use in longwall mining faces to the United States and they have been excellent in shaft production and were well-received by users. We have also recently organized manufacturing of sets of equipment for coal mines in several foreign countries. This has changed China's situation of relying on imports for fully mechanized mining equipment and created an excellent beginning for expanding exports of China's mechanized coal mining equipment.

To adapt to the continual increase in the complexity of coal mine user demand structures and provide coal mines with products that have excellent properties and reliable operation, the coal mine machinery manufacturing industry is now adopting measures in three areas: 1) Relying on S&T progress, extending new technologies, developing new products, and improving product quality; 2) actively implementing overall optimization of enterprise management, reinforcing management, and making comprehensive improvements in enterprise quality and employee quality with the goal of raising enterprise grades; 3) importing technologies, cooperative manufacturing, and using exports to develop imports. In the areas of relying on S&T progress and developing new products, the main thing is development and outfitting by levels oriented toward all of China's large, medium-sized, and small coal mines. At the same time, we are taking aim at high productivity and high output, attacking key problems with high power, high strength, and handling large amounts of coal, achieving one work face and one tunneling head for each mine, and monthly coal output of 100,000 tons. We are now concentrating on developing 1,000-ton working pressure hydraulic supports, 750 kW coal extractors, 500 kW conveyors, electro-hydraulic control, and other projects and striving to catch up with world levels. In the area of implementing overall optimization of enterprise management and reinforcing management, we are focusing on rational and optimized organization of the factors of production, intensifying comprehensive quality management, strict technical discipline, and stronger quantitative management. In the area of technology imports and cooperative manufacturing, we are combining imports of equipment with technology imports to improve product technology levels and using cooperative manufacturing in economic development zones, exports to third parties, and some domestic sales to increase the development strengths of coal mine machinery manufacturing.

Enormous changes have occurred in China's coal mine machinery manufacturing industry over the past 40 years and it has made important contributions to modernizing China's coal industry. However, it obviously lags behind world levels and there are obvious inadequacies relative to the needs of coal industry development. We are using the opportunity of this World Mining Conference to take advantage of our strong points and compensate for our weak points. We desire exchanges and cooperation with colleagues in all parts of the world.

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